TEXAS INSTRUMENTS

SN65HVD30, SN65HVD31, SN65HVD32
SN65HVD33, SN65HVD34, SN65HVD35

SLLS665K – SEPTEMBER 2005 – REVISED OCTOBER 2015

SN65HVD3x 3.3-V Full-Duplex RS-485 Drivers and Receivers

1 Features

- 1/8 Unit-Load Option Available (Up to 256 Nodes on the Bus)
- Bus-Pin ESD Protection Exceeds 15-kV HBM
- Optional Driver Output Transition Times for Signaling Rates of 1 Mbps, 5 Mbps and 26 Mbps
  - Line Signaling Rate is the Number of Voltage Transitions Made per Second Expressed in Units of bps (bits per second)
- Low-Current Standby Mode: <1 µA
- Glitch-Free Power-Up and Power-Down Protection for Hot-Plugging Applications
- 5-V Tolerant Inputs
- Bus Idle, Open, and Short-Circuit Failsafe
- Driver Current Limiting and Thermal Shutdown
- Designed for RS-422 and RS-485 Networks
- 5-V Devices Available, SN65HVD50-55

2 Applications

- Utility Meters
- DTE and DCE Interfaces
- Industrial, Process, and Building Automation
- Point-of-Sale (POS) Pins and Networks

3 Description

The SN65HVD3x devices are 3-state differential line drivers and differential-input line receivers that operate with 3.3-V power supply.

Each driver and receiver has separate input and output pins for full-duplex bus communication designs. They are designed for RS-422 and RS-485 data transmission over cable lengths of up to 1500 meters.

The SN65HVD30, SN65HVD31, and SN65HVD32 devices are fully enabled with no external enabling pins.

The SN65HVD33, SN65HVD34, and SN65HVD35 devices have active-high driver enables and active-low receiver enables. A low, less than 1 µA, standby current can be achieved by disabling both the driver and receiver.

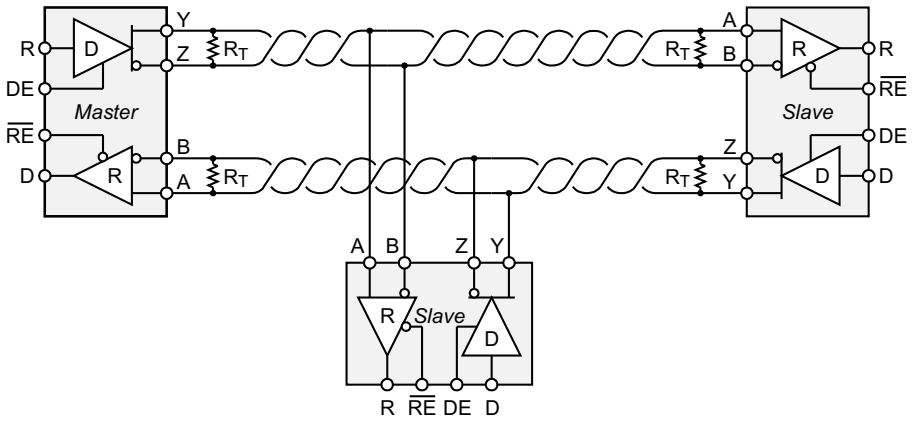
All devices are characterized for ambient temperatures from –40°C to 85°C. Low power dissipation allows operation at temperatures up to 105°C or 125°C, depending on package option.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN65HVD30	SOIC (8)	4.90 mm × 3.91 mm
SN65HVD31		
SN65HVD32		
SN65HVD33	SOIC (14)	8.65 mm × 3.91 mm
	VQFN (20)	4.50 mm × 3.50 mm
SN65HVD34	SOIC (14)	8.65 mm × 3.91 mm
SN65HVD35		

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application Schematic



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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision J (July 2015) to Revision K **Page**

- Changed device listing in the Device Information table to match the Package Option Addendum listing. ... 1
- Changed device listing in the Pinout Configuration section to match the Package Option Addendum listing. ... 4
- Changed device listing in the Thermal Information table to match the Package Option Addendum listing. ... 6

Changes from Revision I (April 2010) to Revision J **Page**

- Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1

5 Device Comparison

Table 1. Device Features

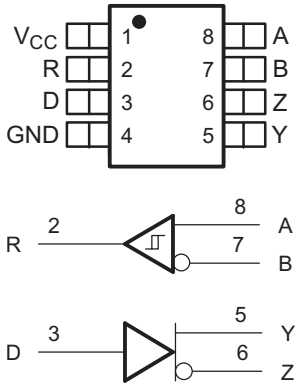
BASE PART NUMBER	SIGNALING RATE	UNIT LOADS	ENABLES
SN65HVD30	26 Mbps	1/2	No
SN65HVD31	5 Mbps	1/8	No
SN65HVD32	1 Mbps	1/8	No
SN65HVD33	26 Mbps	1/2	Yes
SN65HVD34	5 Mbps	1/8	Yes
SN65HVD35	1 Mbps	1/8	Yes

Table 2. Improved Replacement for Devices

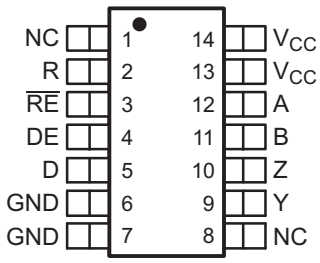
PART NUMBER	REPLACE WITH	BENEFITS
MAX3491 MAX3490	SN65HVD33 SN65HVD30	Better ESD protection (15 kV versus 2 kV, or not specified) Higher Signaling Rate (26 Mbps versus 10 Mbps) Fractional Unit Load (64 Nodes versus 32)
MAX3491E MAX3490E	SN65HVD33 SN65HVD30	Higher Signaling Rate (26 Mbps versus 12 Mbps) Fractional Unit Load (64 Nodes versus 32)
MAX3076E MAX3077E	SN65HVD33 SN65HVD30	Higher Signaling Rate (26 Mbps versus 16 Mbps) Lower Standby Current (1 µA versus 10 µA)
MAX3073E MAX3074E	SN65HVD34 SN65HVD31	Higher Signaling Rate (5 Mbps versus 500 kbps) Lower Standby Current (1 µA versus 10 µA)
MAX3070E MAX3071E	SN65HVD35 SN65HVD32	Higher Signaling Rate (1 Mbps versus 250 kbps) Lower Standby Current (1 µA versus 10 µA)

6 Pin Configuration and Functions

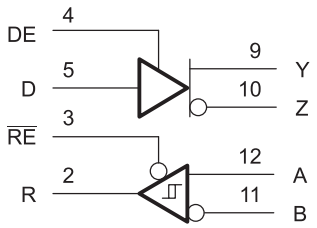
SN65HVD30, SN65HVD31, SN65HVD32, D Package
8-Pin SOIC
Top View



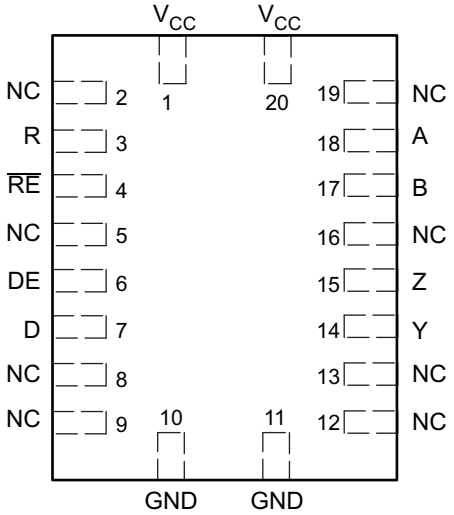
SN65HVD33, SN65HVD34, SN65HVD35 D Package
14-Pin SOIC
Top View



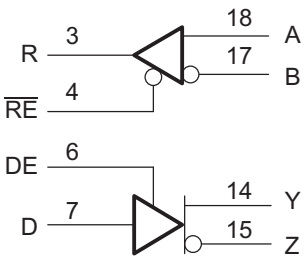
NC - No internal connection
Pins 6 and 7 are connected together internally
Pins 13 and 14 are connected together internally



SN65HVD33 RHL Package
20-Pin VQFN
Top View



NC - No internal connection
Pins 10 and 11 are connected together internally
Pins 1 and 20 are connected together internally



Pin Functions

PIN				TYPE	DESCRIPTION
NAME	D (8-Pins)	D (14-Pins)	RHL (20-Pins)		
A	8	12	18	Bus input	Receiver input (complementary to B)
B	7	11	17	Bus input	Receiver input (complementary to A)
D	3	5	7	Digital input	Driver data input
DE	—	4	6	Digital input	Driver enable, active high
GND	4	6, 7	10, 11	Reference potential	Local device ground
NC	—	1, 8	2, 5, 8, 9, 12, 13, 16, 19	No connect	No connect; must be left floating
R	2	2	3	Digital output	Receive data output
$\overline{RE}$	—	3	4	Digital output	Receiver enable, active low
V_{CC}	1	13, 14	1, 20	Supply	3-V to 3.6-V supply
Y	5	9	14	Bus output	Driver output (complementary to Z)
Z	6	10	15	Bus output	Driver output (complementary to Y)

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range unless otherwise noted(1)(2)

		MIN	MAX	UNIT
V_{CC}	Supply voltage	–0.3	6	V
$V_{(A)}$, $V_{(B)}$, $V_{(Y)}$, $V_{(Z)}$	Voltage at any bus terminal (A, B, Y, Z)	–9	14	V
$V_{(TRANS)}$	Voltage input, transient pulse through 100 Ω. See Figure 28 (A, B, Y, Z)(3)	–50	50	V
V_I	Input voltage (D, DE, $\overline{RE}$)	–0.5	7	V
I_O	Output current (receiver output only, R)		11	mA
T_{stg}	Storage Temperature		125	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
(3) This tests survivability only and the output state of the receiver is not specified.

7.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	Bus pins and GND	±16000	V
			All pins	±4000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)		±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating free-air temperature range unless otherwise noted

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		3		3.6	V
V_I or V_{IC}	Voltage at any bus pin (separately or common mode)		–7 (1)		12	V
$1/t_{UI}$	Signaling rate	SN65HVD30, SN65HVD33			26	Mbps
		SN65HVD31, SN65HVD34			5	
		SN65HVD32, SN65HVD35			1	
R_L	Differential load resistance		54	60		Ω
V_{IH}	High-level input voltage	D, DE, $\overline{RE}$	2		V_{CC}	V
V_{IL}	Low-level input voltage	D, DE, $\overline{RE}$	0		0.8	V
V_{ID}	Differential input voltage		–12		12	V
I_{OH}	High-level output current	Driver	–60			mA
		Receiver	–8			
I_{OL}	Low-level output current	Driver			60	mA
		Receiver			8	
T_J	Junction temperature		–40		150	°C

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

7.4 Thermal Information

THERMAL METRIC (1)		SN65HVD30, SN65HVD31, SN65HVD32	SN65HVD33, SN65HVD34, SN65HVD35	SN65HVD33	UNIT
		D (SOIC)	D (SOIC)	RHL (VQFN)	
		8 PINS	14 PINS	20 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	135	92	73	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	43	59	14	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	44	61	13.7	°C/W
ψ_{JT}	Junction-to-top characterization parameter	12.1	5.7	0.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	49.7	30.7	13.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	2.8	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

7.5 Electrical Characteristics: Driver

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
$V_{I(K)}$	Input clamp voltage		I_I = –18 mA	–1.5			V
$\lvert V_{OD(SS)}\rvert$	Steady-state differential output voltage		I_O = 0	2.5		V_{CC}	V
			R_L = 54 Ω, See Figure 17 (RS-485)	1.5	2		
			R_L = 100 Ω, See Figure 17,(2) (RS-422)	2	2.3		
			V_{test} = –7 V to 12 V, See Figure 18	1.5			
$\Delta\lvert V_{OD(SS)}\rvert$	Change in magnitude of steady-state differential output voltage between states		R_L = 54 Ω, See Figure 17 and Figure 18	–0.2		0.2	V
$V_{OD(RING)}$	Differential Output Voltage overshoot and undershoot		R_L = 54 Ω, C_L = 50 pF, See Figure 21 and Figure 19			10%(3)	V
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	SN65HVD30, SN65HVD33	See Figure 20		0.5		V
		SN65HVD31, SN65HVD34, SN65HVD32, SN65HVD35	See Figure 20		0.25		
$V_{OC(SS)}$	Steady-state common-mode output voltage		See Figure 20	1.6		2.3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage		See Figure 20	–0.05		0.05	V
$I_{Z(Z)}$ or $I_{Y(Z)}$	High-impedance state output current	SN65HVD30, SN65HVD31, SN65HVD32	V_{CC} = 0 V, V_Z or V_Y = 12 V, Other input at 0 V			90	μA
			V_{CC} = 0 V, V_Z or V_Y = –7 V, Other input at 0 V	–10			
		SN65HVD33, SN65HVD34, SN65HVD35	V_{CC} = 3 V or 0 V, DE = 0 V V_Z or V_Y = 12 V Other input at 0 V			90	
			V_{CC} = 3 V or 0 V, DE = 0 V V_Z or V_Y = –7 V Other input at 0 V	–10			
$I_{Z(S)}$ or $I_{Y(S)}$	Short Circuit output current(4)		V_Z or V_Y = –7 V Other input at 0 V	–250		250	mA
			V_Z or V_Y = 12 V Other input at 0 V	–250		250	
I_I	Input current	D, DE		0		100	μA
$C_{(OD)}$	Differential output capacitance		V_{OD} = 0.4 sin (4E6πt) + 0.5 V, DE at 0 V		16		pF

(1) All typical values are at 25°C and with a 3.3-V supply.
(2) V_{CC} is 3.3 V_{DC} ± 5%.
(3) 10% of the peak-to-peak differential output voltage swing, per TIA/EIA-485.
(4) Under some conditions of short-circuit to negative voltages, output currents exceeding the ANSI TIA/EIA-485-A maximum current of 250 mA may occur. Continuous exposure can affect device reliability. This applies to the SN65HVD30, SN65HVD31, SN65HVD33, and SN65HVD34.

7.6 Electrical Characteristics: Receiver

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
V_{IT+}	Positive-going differential input threshold voltage		I_O = –8 mA			–0.02	V
V_{IT-}	Negative-going differential input threshold voltage		I_O = 8 mA	–0.20			V
V_{hys}	Hysteresis voltage ($V_{IT+} – V_{IT–}$)				50		mV
V_{IK}	Enable-input clamp voltage		I_I = –18 mA	–1.5			V
V_O	Output voltage		V_{ID} = 200 mV, I_O = –8 mA, See Figure 24	2.4			V
			V_{ID} = –200 mV, I_O = 8 mA, See Figure 24			0.4	
$I_{O(Z)}$	High-impedance-state output current		V_O = 0 or V_{CC}, $\overline{RE}$ at V_{CC}	–1		1	µA
I_A or I_B	Bus input current	SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35	V_A or V_B = 12 V, Other input at 0 V		0.05	0.1	mA
			V_A or V_B = 12 V, V_{CC} = 0 V, Other input at 0 V		0.06	0.1	
			V_A or V_B = –7 V, Other input at 0 V	–0.10	–0.04		
			V_A or V_B = –7 V, V_{CC} = 0 V, Other input at 0 V	–0.10	–0.03		
		SN65HVD30, SN65HVD33	V_A or V_B = 12 V, Other input at 0 V		0.20	0.35	mA
			V_A or V_B = 12 V, V_{CC} = 0 V, Other input at 0 V		0.24	0.4	
			V_A or V_B = –7 V, Other input at 0 V	–0.35	–0.18		
			V_A or V_B = –7 V, V_{CC} = 0 V, Other input at 0 V	–0.25	–0.13		
I_{IH}	Input current, $\overline{RE}$		V_{IH} = 0.8 V or 2 V	–60			µA
C_{ID}	Differential input capacitance		V_{ID} = 0.4 sin (4E6πt) + 0.5 V, DE at 0 V		15		pF

(1) All typical values are at 25°C and with a 3.3-V supply.

7.7 Device Power Dissipation – P_D

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_D	Power Dissipation (worst case) Driver and receiver enabled, 50% duty cycle square-wave signal at signaling rate: SN65HVD30, SN65HVD33 at 25 Mbps, SN65HVD31, SN65HVD34 at 5 Mbps, SN65HVD32, SN65HVD35 at 1 Mbps	SN65HVD30, SN65HVD33	V_{CC} = 3.6 V, T_J = 140°C, R_L = 54 Ω, C_L = 50 pF (driver), C_L = 15 pF (receiver)			197	mW
		SN65HVD31, SN65HVD34	V_{CC} = 3.6 V, T_J = 140°C, R_L = 54 Ω, C_L = 50 pF (driver), C_L = 15 pF (receiver)			213	
		SN65HVD32, SN65HVD35	V_{CC} = 3.6 V, T_J = 140°C, R_L = 54 Ω, C_L = 50 pF (driver), C_L = 15 pF (receiver)			248	
T_{SD}	Thermal Shut-down Junction Temperature				170		°C

7.8 Supply Current Characteristics

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
I_{CC}	Supply current	SN65HVD30	D at 0 V or V_{CC} and No Load			2.1	mA
		SN65HVD31, SN65HVD32			3.8	6.4	
		SN65HVD33	$\overline{RE}$ at 0 V, D at 0 V or V_{CC}, DE at 0 V, No load (Receiver enabled and driver disabled)			1.8	mA
		SN65HVD34, SN65HVD35				2.2	
		SN65HVD33, SN65HVD34, SN65HVD35	$\overline{RE}$ at V_{CC}, D at V_{CC}, DE at 0 V, No load (Receiver disabled and driver disabled)		0.022	1	µA
		SN65HVD33	$\overline{RE}$ at 0 V, D at 0 V or V_{CC}, DE at V_{CC}, No load (Receiver enabled and driver enabled)			2.1	mA
		SN65HVD34, SN65HVD35				6.5	
		SN65HVD33	$\overline{RE}$ at V_{CC}, D at 0 V or V_{CC}, DE at V_{CC} No load (Receiver disabled and driver enabled)			1.8	mA
		SN65HVD34, SN65HVD35				6.2	

(1) All typical values are at 25°C and with a 3.3-V supply.

7.9 Switching Characteristics: Driver

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	SN65HVD30, SN65HVD33	R_L = 54 Ω, C_L = 50 pF, See Figure 21	4	10	18	ns
		SN65HVD31, SN65HVD34		25	38	65	
		SN65HVD32, SN65HVD35		120	175	305	
t_{PHL}	Propagation delay time, high-to-low-level output	SN65HVD30, SN65HVD33		4	9	18	ns
		SN65HVD31, SN65HVD34		25	38	65	
		SN65HVD32, SN65HVD35		120	175	305	
t_r	Differential output signal rise time	SN65HVD30, SN65HVD33		2.5	5	12	ns
		SN65HVD31, SN65HVD34		20	37	60	
		SN65HVD32, SN65HVD35		120	185	300	
t_f	Differential output signal fall time	SN65HVD30, SN65HVD33		2.5	5	12	ns
		SN65HVD31, SN65HVD34		20	35	60	
		SN65HVD32, SN65HVD35		120	180	300	
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)	SN65HVD30, SN65HVD33			0.6		ns
		SN65HVD31, SN65HVD34			2.0		
		SN65HVD32, SN65HVD35			5.1		

(1) All typical values are at 25°C and with a 3.3-V supply.

Switching Characteristics: Driver (continued)

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{PZH1}	Propagation delay time, high-impedance-to-high-level output	SN65HVD33	R_L = 110 Ω, $\overline{RE}$ at 0 V, D = 3 V and S1 = Y, or D = 0 V and S1 = Z See Figure 22			45	ns
		SN65HVD34				235	
		SN65HVD35				490	
t_{PHZ}	Propagation delay time, high-level-to-high-impedance output	SN65HVD33				25	ns
		SN65HVD34				65	
		SN65HVD35				165	
t_{PZL1}	Propagation delay time, high-impedance-to-low-level output	SN65HVD33	R_L = 110 Ω, $\overline{RE}$ at 0 V, D = 3 V and S1 = Z, or D = 0 V and S1 = Y See Figure 23			35	ns
		SN65HVD34				190	
		SN65HVD35				490	
t_{PLZ}	Propagation delay time, low-level-to-high-impedance output	SN65HVD33				30	ns
		SN65HVD34				120	
		SN65HVD35				290	
t_{PZH1}, t_{PZL1}	Driver enable delay with bus voltage offset		V_O= 2 V (Typ)		500	900	ns
t_{PZH2}	Propagation delay time, standby-to-high-level output		R_L = 110 Ω, $\overline{RE}$ at 3 V, D = 3 V and S1 = Y, or D = 0 V and S1 = Z See Figure 22			4000	ns
t_{PZL2}	Propagation delay time, standby-to-low-level output		R_L = 110 Ω, $\overline{RE}$ at 3 V, D = 3 V and S1 = Z, or D = 0 V and S1 = Y See Figure 23			4000	ns

7.10 Switching Characteristics: Receiver

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS		MIN	TYP(1)	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	SN65HVD30, SN65HVD33	V_{ID} = –1.5 V to 1.5 V, C_L = 15 pF, See Figure 25			26	45	ns
		SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35				47	70	ns
t_{PHL}	Propagation delay time, high-to-low-level output	SN65HVD30, SN65HVD33				29	45	ns
		SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35				49	70	ns
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)	SN65HVD30, SN65HVD33					7	ns
		SN65HVD31, SN65HVD34, SN65HVD32, SN65HVD35					10	ns
t_r	Output signal rise time						5	ns
t_f	Output signal fall time						6	ns
t_{PHZ}	Output disable time from high level		DE at 3 V	C_L = 15 pF, See Figure 26			20	ns
t_{PZH1}	Output enable time to high level						20	ns
t_{PZH2}	Propagation delay time, standby-to-high-level output		DE at 0 V				4000	ns
t_{PLZ}	Output disable time from low level		DE at 3 V	C_L = 15 pF, See Figure 27			20	ns
t_{PZL1}	Output enable time to low level						20	ns
t_{PZL2}	Propagation delay time, standby-to-low-level output		DE at 0 V				4000	ns

(1) All typical values are at 25°C and with a 3.3-V supply.

7.11 Dissipation Ratings

PACKAGE	JEDEC THERMAL MODEL	T_A < 25°C RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 85°C RATING	T_A = 105°C RATING	T_A = 125°C RATING
8-pin D (SOIC)	Low k	625 mW	5 mW/°C	325 mW		
	High k	1000 mW	8 mW/°C	520 mW	360 mW	
14-pin D (SOIC)	Low k	765 mW	6.1 mW/°C	400 mW	275 mW	
	High k	1350 mW	10.8 mW/°C	705 mW	485 mW	270 mW
20-pin RHL (VQFN)	High k	1710 mW	13.7 mW/°C	890 mW	6150 mW	340 mW

7.12 Typical Characteristics

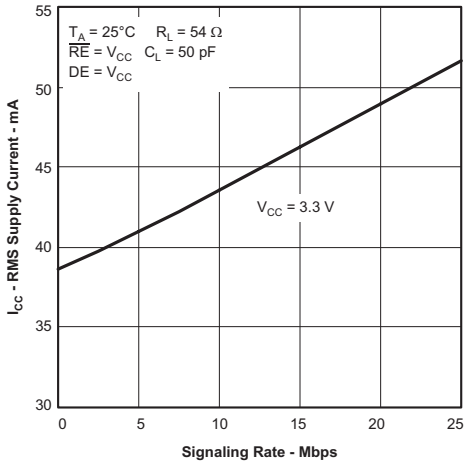


Figure 1. SN65HVD30, SN65HVD33 RMS Supply Current vs Signaling Rate

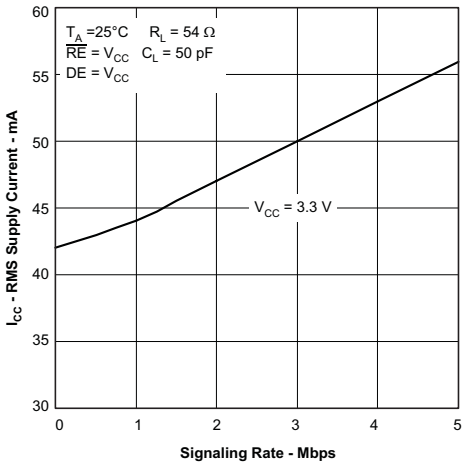


Figure 2. SN65HVD31, SN65HVD34 RMS Supply Current vs Signaling Rate

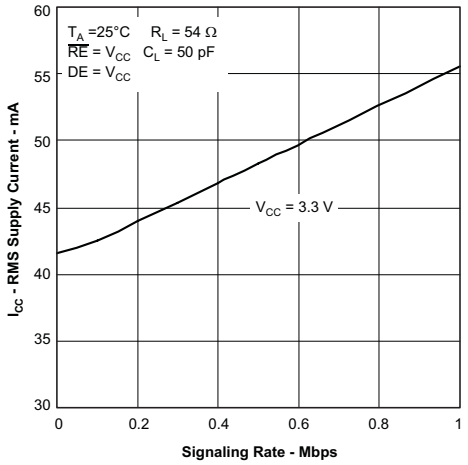


Figure 3. SN65HVD32, SN65HVD35 RMS Supply Current vs Signaling Rate

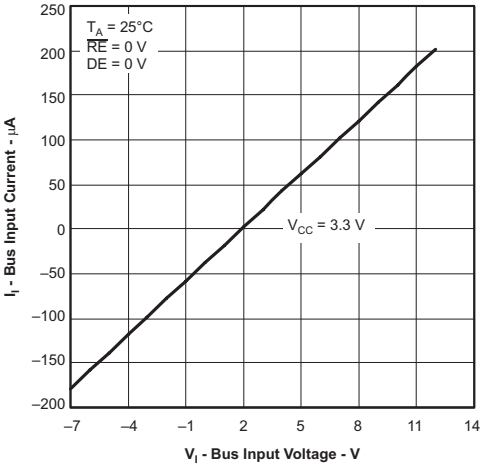


Figure 4. SN65HVD30, SN65HVD33 Bus Input Current vs Input Voltage

Typical Characteristics (continued)

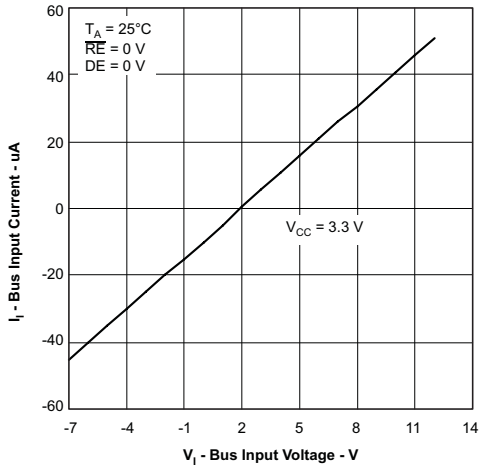


Figure 5. SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35 Bus Input Current vs Input Voltage

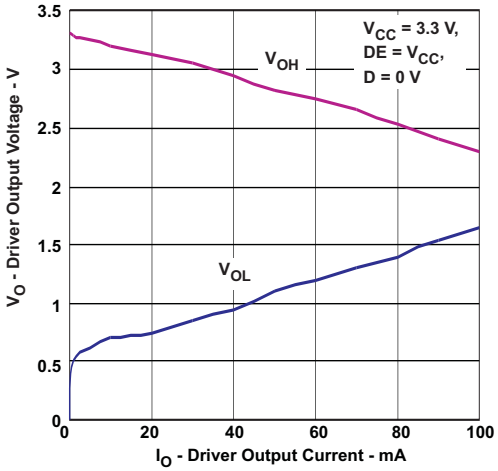


Figure 6. Driver Output Voltage vs Driver Output Current

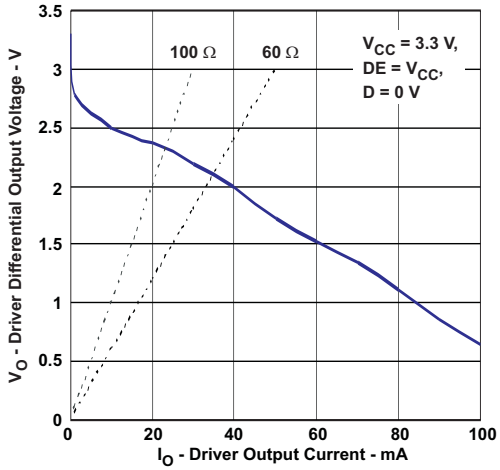


Figure 7. Driver Differential Output Voltage vs Driver Output Current

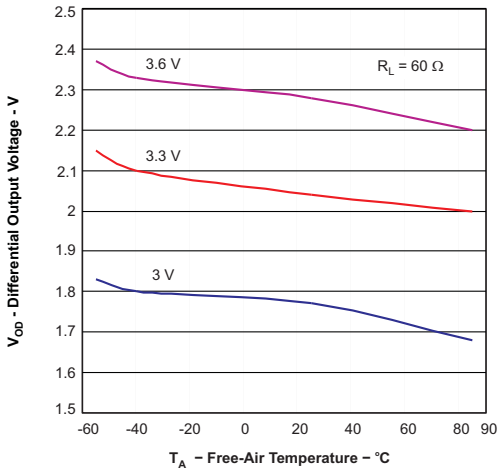


Figure 8. Driver Differential Output Voltage vs Free-Air Temperature

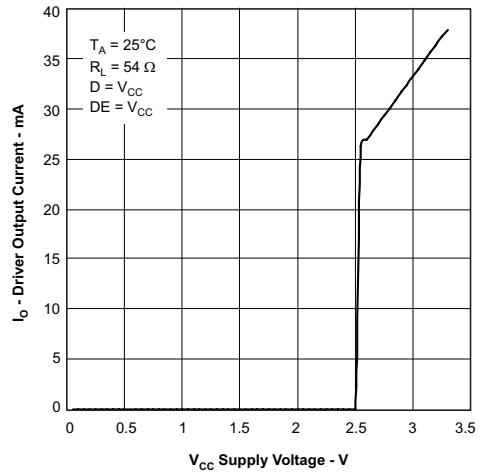


Figure 9. Driver Output Current vs Supply Voltage

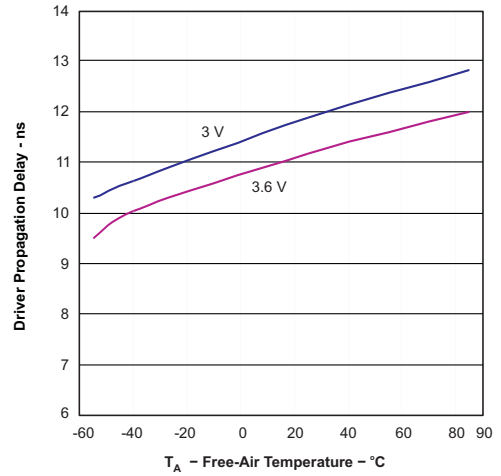


Figure 10. SN65HVD30, SN65HVD33 Driver Propagation Delay vs Free-Air Temperature

Typical Characteristics (continued)

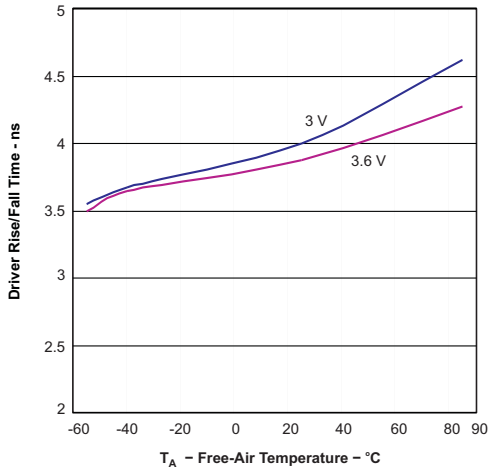


Figure 11. SN65HVD30, SN65HVD33 Driver Rise and Fall Time vs Free-Air Temperature

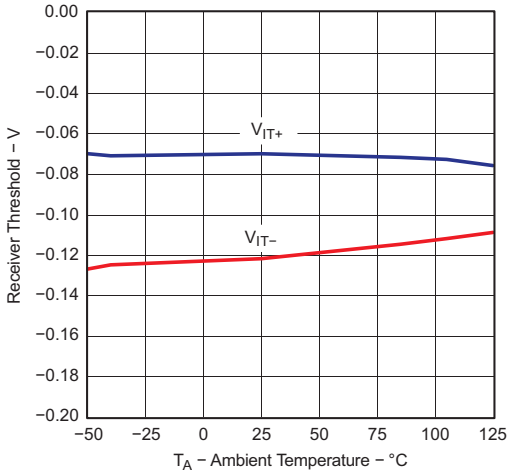


Figure 12. Receiver Threshold vs Ambient Temperature

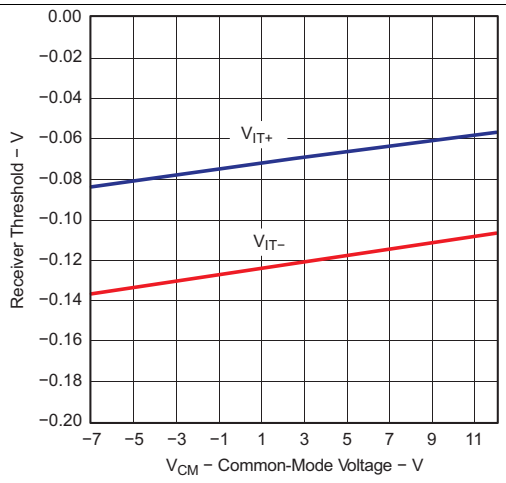


Figure 13. Receiver Threshold vs Common-Mode Voltage

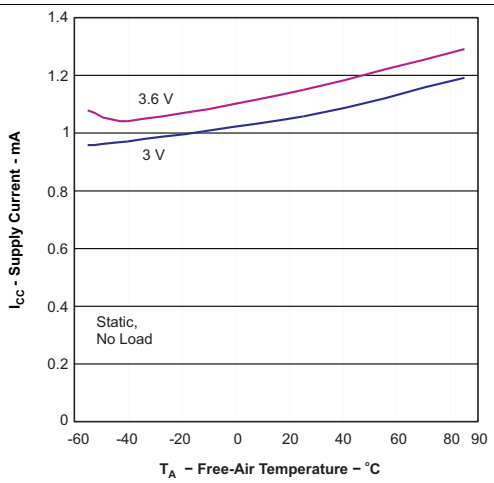


Figure 14. Supply Current vs Free-Air Temperature

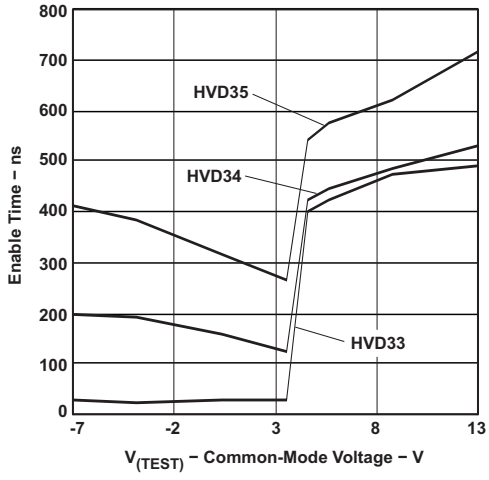
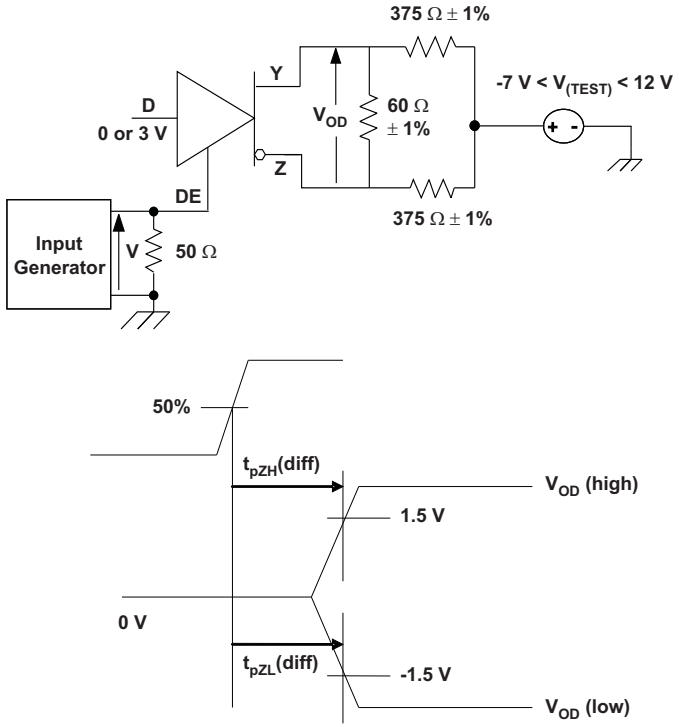


Figure 15. Enable Time vs Common-Mode Voltage (see Figure 16)

8 Parameter Measurement Information



The time $t_{pZL}(x)$ is the measure from DE to $V_{OD}(x)$. V_{OD} is valid when it is greater than 1.5 V.

Figure 16. Driver Enable Time From DE to V_{OD}

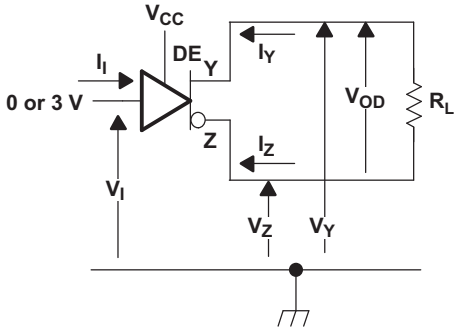


Figure 17. Driver V_{OD} Test Circuit and Voltage and Current Definitions

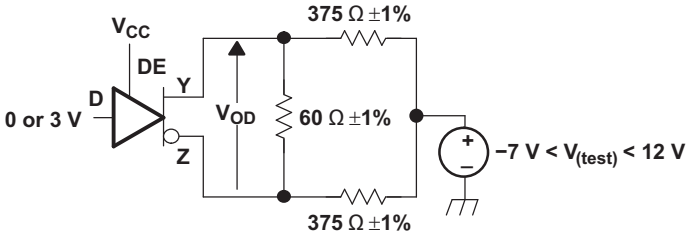


Figure 18. Driver V_{OD} With Common-Mode Loading Test Circuit

Parameter Measurement Information (continued)

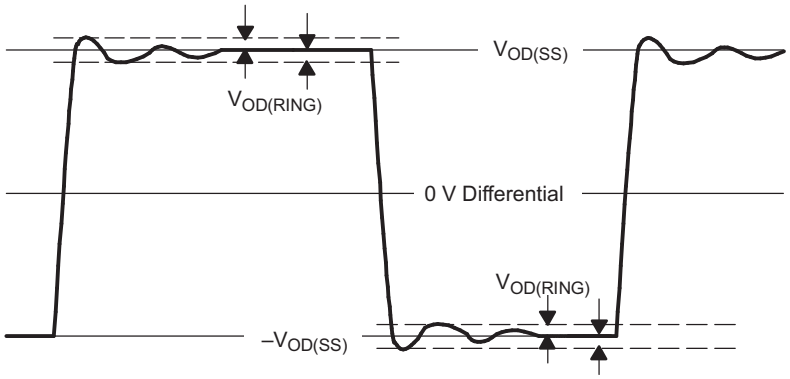
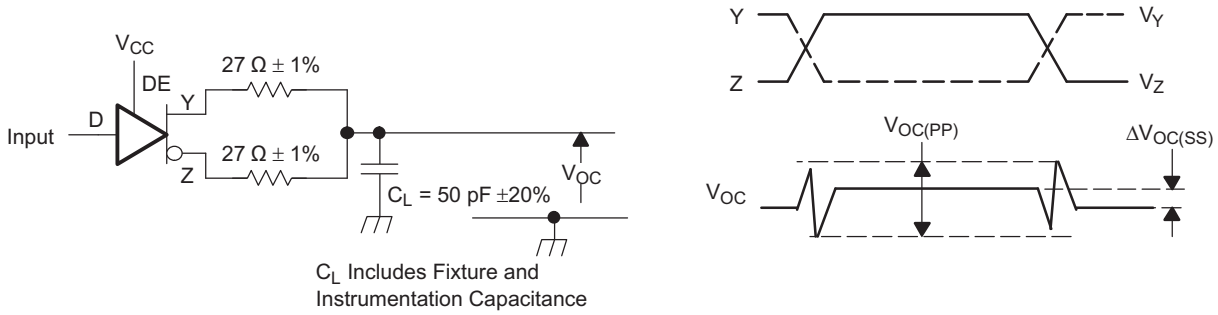


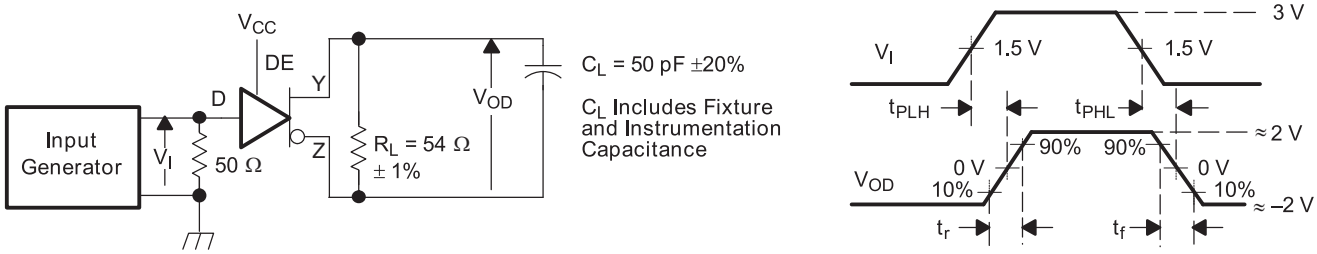
Figure 19. $V_{OD(RING)}$ Waveform and Definitions

$V_{OD(RING)}$ is measured at four points on the output waveform, corresponding to overshoot and undershoot from the $V_{OD(H)}$ and $V_{OD(L)}$ steady state values.



Input: PRR = 500 kHz, 50% Duty Cycle,t $_r$<6ns, t_f<6ns, Z_O = 50 Ω

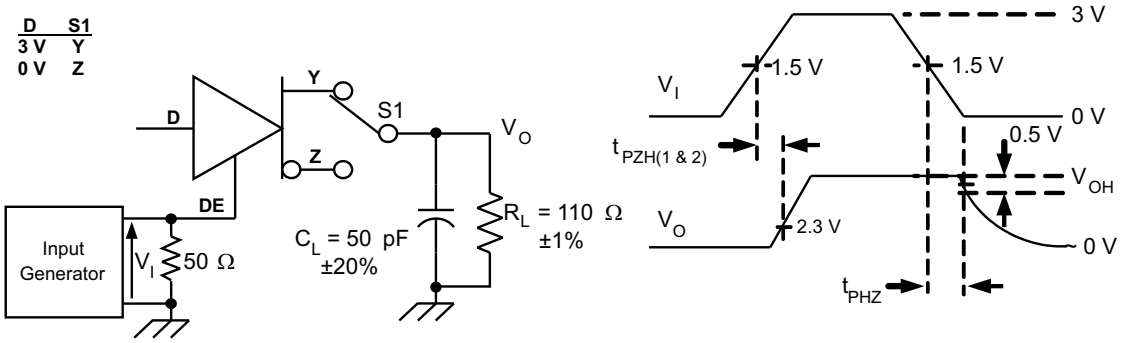
Figure 20. Test Circuit and Definitions for the Driver Common-Mode Output Voltage



Generator: PRR = 500 kHz, 50% Duty Cycle, t_r <6 ns, t_f <6 ns, Z_o = 50 Ω

Figure 21. Driver Switching Test Circuit and Voltage Waveforms

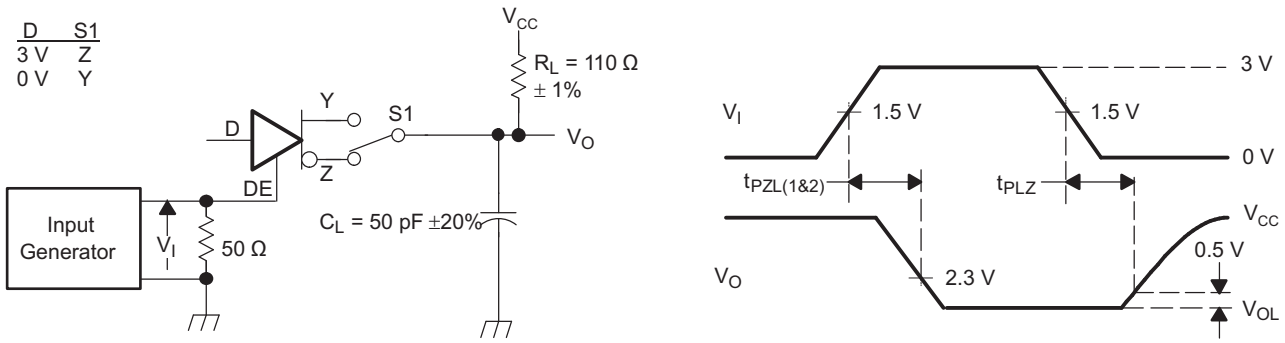
Parameter Measurement Information (continued)



Generator: PRR = 50 kHz, 50% Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

C_L Includes Fixture and Instrumentation Capacitance

Figure 22. Driver High-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms



Generator: PRR = 50 kHz, 50% Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

C_L Includes Fixture and Instrumentation Capacitance

Figure 23. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

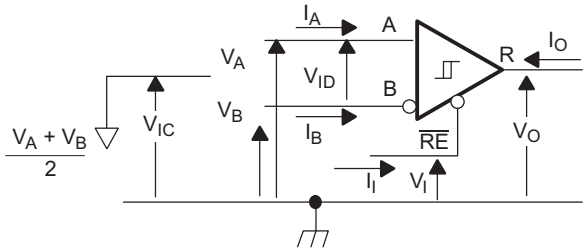
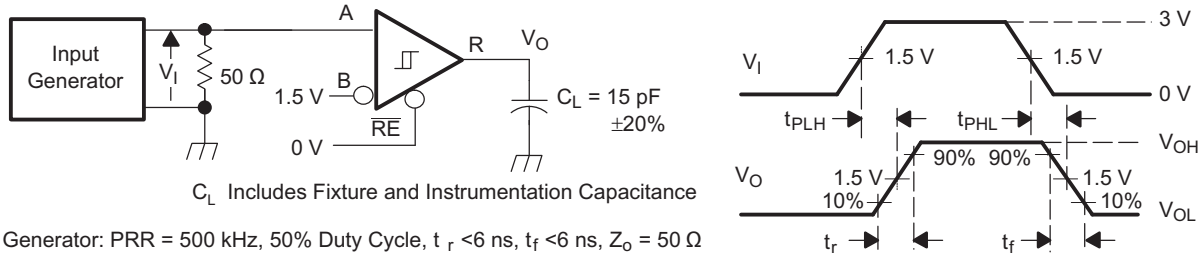


Figure 24. Receiver Voltage and Current Definitions

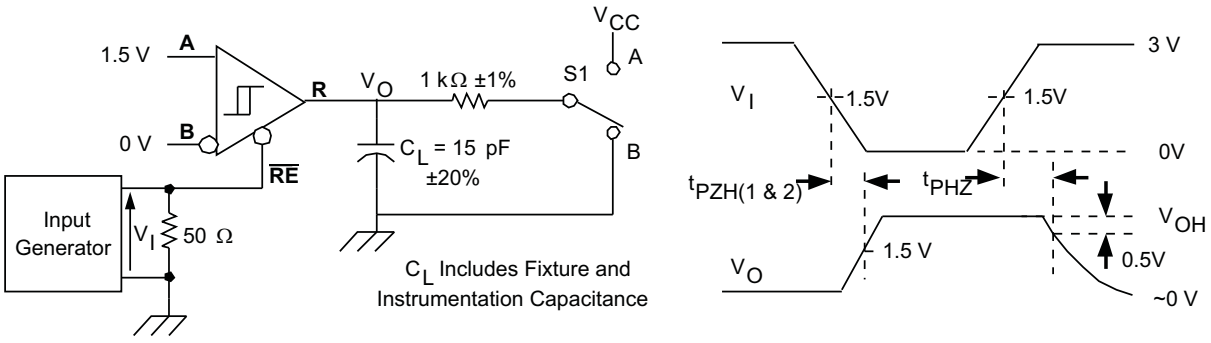


C_L Includes Fixture and Instrumentation Capacitance

Generator: PRR = 500 kHz, 50% Duty Cycle, t_r <6 ns, t_f <6 ns, Z_o = 50 Ω

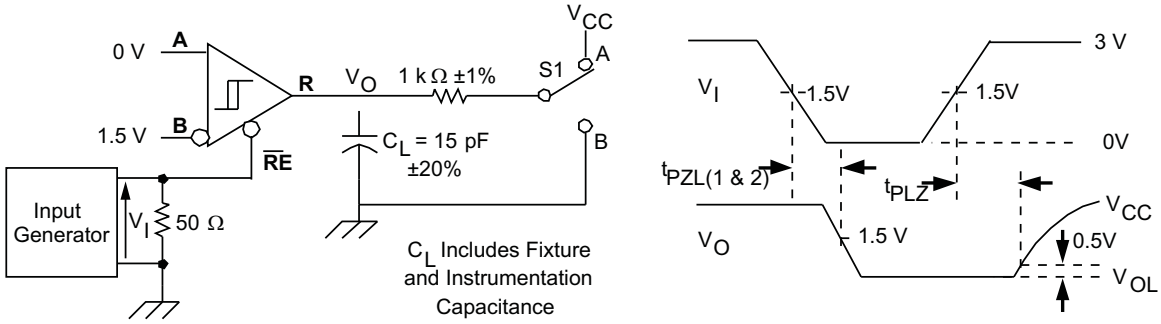
Figure 25. Receiver Switching Test Circuit and Voltage Waveforms

Parameter Measurement Information (continued)



Generator: PRR = 50 kHz, 50% Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

Figure 26. Receiver High-Level Enable and Disable Time Test Circuit and Voltage Waveforms



Generator: PRR = 50 kHz, 50% Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

Figure 27. Receiver Enable Time From Standby (Driver Disabled)

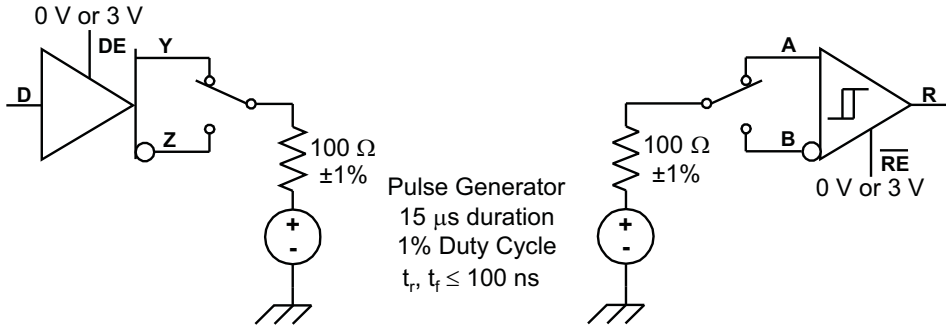


Figure 28. Test Circuit, Transient Over Voltage Test

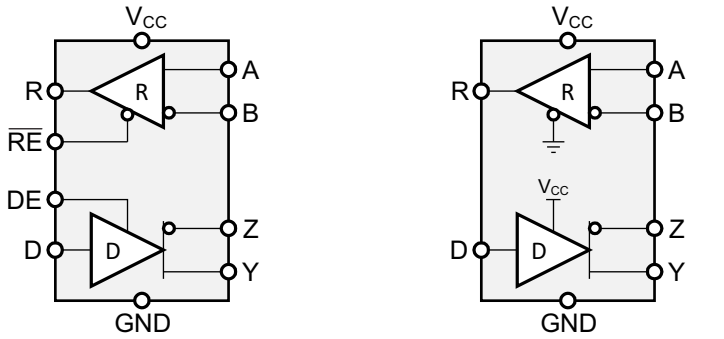
9 Detailed Description

9.1 Overview

The SN65HVD3x devices are low-power, full-duplex RS-485 transceivers available in three speed grades suitable for data transmission of 1 Mbps, 5 Mbps, and 50 Mbps.

The SN65HVD30, SN65HVD31, and SN65HVD32 devices are fully enabled with no external enabling pins. The SN65HVD33, SN65HVD34, and SN65HVD35 devices have active-high driver enables and active-low receiver enables. A standby current of less than 1 µA can be achieved by disabling both driver and receiver.

9.2 Functional Block Diagram



a) SN65HVD33, SN65HVD34, SN65HVD35

b) SN65HVD30, SN65HVD31, SN65HVD32

9.3 Feature Description

9.3.1 Low-Power Standby Mode

When both the driver and receiver are disabled (DE is low and $\overline{RE}$ is high), the device is in standby mode. If the enable inputs are in this state for less than 60 ns, the device does not enter standby mode. This guards against inadvertently entering standby mode during driver or receiver enabling. The device in standby mode only when the enable inputs are held in this state for 300 ns or more. In this low-power standby mode, most internal circuitry is powered down, and the supply current is typically less than 1 nA. When either the driver or the receiver is re-enabled, the internal circuitry becomes active.

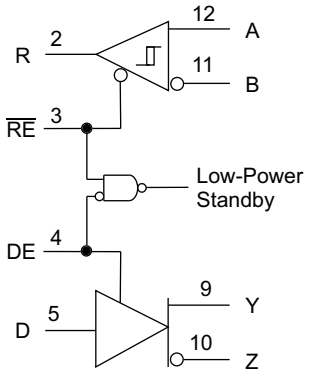


Figure 29. Low-Power Standby Logic Diagram

If only the driver is re-enabled (DE transitions to high) the driver outputs are driven according to the D input after the enable times given by t_{PZH2} and t_{PZL2} in the driver switching characteristics. If the D input is open when the driver is enabled, the driver output defaults to Y high and Z low, in accordance with the driver-failsafe feature.

Feature Description (continued)

If only the receiver is re-enabled ($\overline{RE}$ transitions to low) the receiver output is driven according to the state of the bus inputs (A and B) after the enable times given by t_{PZH2} and t_{PZL2} in the receiver switching characteristics. If there is no valid state on the bus the receiver responds as described in the failsafe operation section.

If both the receiver and driver are re-enabled simultaneously, the receiver output is driven according to the state of the bus inputs (A and B) and the driver output is driven according to the D input. Note that the state of the active driver affects the inputs to the receiver. Therefore, the receiver outputs are valid as soon as the driver outputs are valid.

9.3.2 Driver Output Current Limiting

The RS-485 standard (ANSI/TIA/EIA-485-A or equivalently ISO 8482) specifies a 250-mA driver output current limit to prevent damage caused by data contention on the bus. That applies in the event that two or more transceivers drive the bus to opposing states at the same time. The SN65HVD3x family of devices includes current-limiting circuitry that prevents damage under these conditions.

NOTE

This current limit prevents damage during the bus contention, but the logic state of the bus can be indeterminate as specified by the standard, so communication errors can occur.

In a specific combination of circumstances, a condition can occur in which current through the bus pin exceeds the 250-mA limit. This combination of conditions is not normally included in RS-485 applications:

- Loading capacitance on the pin is less than 500 pF
- The bus pin is directly connected to a voltage more negative than –1 V
- The device is supplied with V_{CC} equal to or greater than 3.3 V
- The driver is enabled
- The bus pin is driving to the logic high state

In these specific conditions, the normal current-limit circuitry and thermal-shutdown circuitry does not limit or shutdown the current flow. If the current is allowed to continue, the device heats up in a localized area near the driver outputs, and the device can be damaged.

Typical RS-485 twisted-pair cable has a capacitance of approximately 50 pF/meter. Therefore, it is expected that 10 meters of cable can provide sufficient capacitance to prevent this latch-up condition.

The –7 to +12-V common mode range specified by RS-485 is intended to allow communication between transceivers separated by significant distances when ground offsets may occur due to temporary current surges, electrical noise, and so on. Under those circumstances, the inherent cable needed to connect separated transceivers ensures that the conditions previously listed do not occur. For a transceiver separated by only a short cable length or backplane applications, it is unusual for there to be a steady-state negative common-mode voltage. It is possible for a negative power supply to be shorted to the bus lines due to miswiring or cable damage; however, this is a different root cause fault, and robust devices such as the SN65HVD178x family should be used for surviving power supply or miswiring faults.

The 250-mA current limit in the RS-485 standard is intended to prevent damage caused by data contention on the bus; that is, in the event that two or more transceivers drive the bus to different states at the same time. These devices are not damaged under these conditions because all RS-485 drivers have output impedance sufficient to prevent the direct connection condition stated previously. Typical RS-485 driver output impedance is on the order of 10 Ω to 30 Ω.

9.3.3 Hot-Plugging

These devices are designed to operate in *hot swap* or *hot pluggable* applications. Key features for hot-pluggable applications are:

- Power-up
- Power-down glitch-free operation
- Default disabled input/output pins
- Receiver failsafe

Feature Description (continued)

As shown in Figure 9, an internal power-on reset circuit keeps the driver outputs in a high-impedance state until the supply voltage has reached a level at which the device reliably operates. This ensures that no spurious bits are transmitted on the bus pin outputs as the power supply turns on or turns off.

As shown in the *Device Functional Modes*, the enable inputs have the feature of default disable on both the driver enable and receiver enable. This ensures that the device neither drives the bus nor reports data on the R pin until the associated controller actively drives the enable pins.

9.3.4 Receiver Failsafe

The differential receivers of the SN65HVD3x family are failsafe to invalid bus states caused by:

- Open bus conditions such as a disconnected connector
- Shorted bus conditions such as cable damage shorting the twisted-pair together
- Idle bus conditions that occur when no driver on the bus is actively driving

In any of these cases, the differential receiver outputs a failsafe logic high state so that the output of the receiver is not indeterminate.

Receiver failsafe is accomplished by offsetting the receiver thresholds such that the input indeterminate range does not include zero volts differential. In order to comply with the RS-422 and RS-485 standards, the receiver output must output a high when the differential input V_{ID} is more positive than 200 mV, and must output a low when V_{ID} is more negative than –200 mV. The receiver parameters which determine the failsafe performance are V_{IT+}, $V_{IT–}$, and V_{HYS} (the separation between V_{IT+} and $V_{IT–}$. As shown in the *Electrical Characteristics* table, differential signals more negative than –200 mV always cause a low receiver output, and differential signals more positive than 200 mV always cause a high receiver output.

When the differential input signal is close to zero, it is still above the V_{IT+} threshold, and the receiver output is high. Only when the differential input is more than V_{HYS} below V_{IT+} does the receiver output transition to a low state. Therefore, the noise immunity of the receiver inputs during a bus fault conditions includes the receiver hysteresis value (V_{HYS}) as well as the value of V_{IT+}.

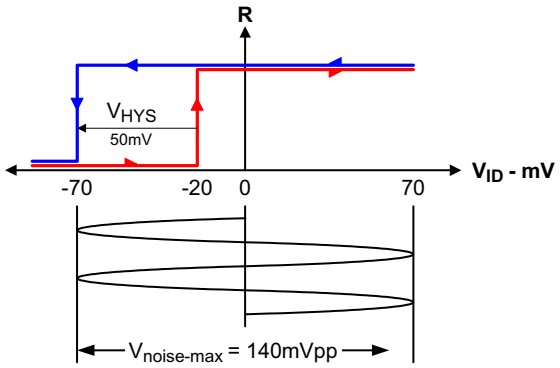


Figure 30. SN65HVD30-35 Noise Immunity Under Bus Fault Conditions

9.3.5 Safe Operation With Bus Contention

These devices incorporate a driver current limit of 250 mA across the RS-485 common-mode range of –7 V to +12 V. As stated in the *Application Guidelines for TIA/EIA-485-A* (1), this sets a practical limitation to prevent damage during bus contention events. Contention can occur during system initialization, during system faults, or whenever two or more drivers are active at the same time.

(1) TIA/EIA Telecommunications System Bulletin TSB89, *Application Guidelines for TIA/EIA-485-A*

Feature Description (continued)

Figure 31 shows a 2-node system to demonstrate bus contention by forcing both drivers to be active in opposing states.

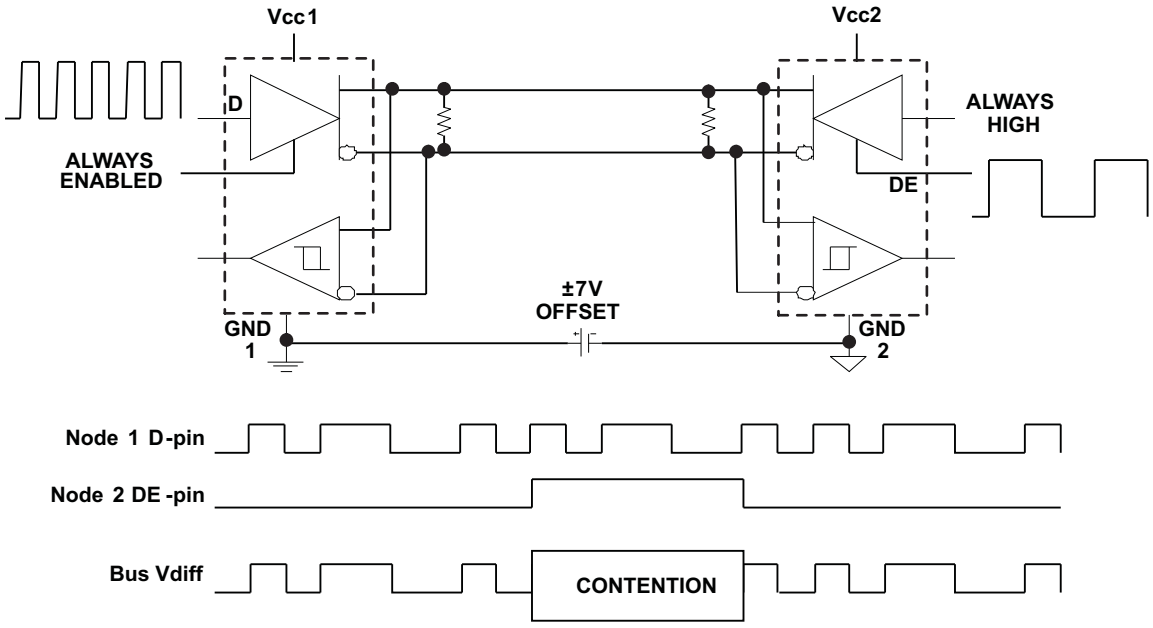


Figure 31. Bus Contention Example

Figure 32 shows typical operation in a bus contention event. The bottom trace illustrates how the SN65HVD33 device at Node 1 continues normal operation after a contention event between the two drivers with a –7-V ground offset on Node 2. This illustrates how the SN65HVD3x family of devices operates robustly in spite of bus contention faults, even with large common-mode offsets.

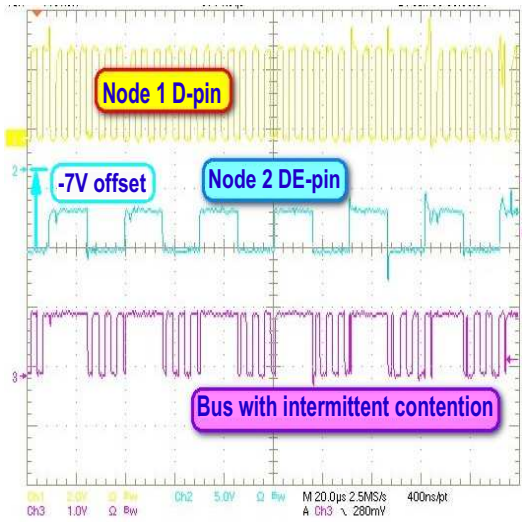


Figure 32. SN65HVD3x Drivers Operate Correctly After Bus Contention Faults

9.4 Device Functional Modes

Table 3. SN65HVD33, SN65HVD34, SN65HVD35 Driver

INPUTS		OUTPUTS	
D	DE	Y	Z
H	H	H	L
L	H	L	H
X	L or open	Z	Z
Open	H	L	H

Table 4. SN65HVD33, SN65HVD34, SN65HVD35 Receiver

DIFFERENTIAL INPUTS $V_{ID} = V_{(A)} - V_{(B)}$	ENABLE $\overline{RE}$	OUTPUT R
$V_{ID} \le -0.2$ V	L	L
-0.2 V $< V_{ID} < -0.02$ V	L	?
-0.02 V $\le V_{ID}$	L	H
X	H or open	Z
Open Circuit	L	H
Idle circuit	L	H
Short Circuit, $V_{(A)} = V_{(B)}$	L	H

Table 5. SN65HVD30, SN65HVD31, SN65HVD32 Driver

INPUT D	OUTPUTS	
	Y	Z
H	H	L
L	L	H
Open	L	H

Table 6. SN65HVD30, SN65HVD31, SN65HVD32 Receiver

DIFFERENTIAL INPUTS $V_{ID} = V_{(A)} - V_{(B)}$	OUTPUT R
$V_{ID} \le -0.2$ V	L
-0.2 V $< V_{ID} < -0.02$ V	?
-0.02 V $\le V_{ID}$	H
Open Circuit	H
Idle circuit	H
Short Circuit, $V_{(A)} = V_{(B)}$	H

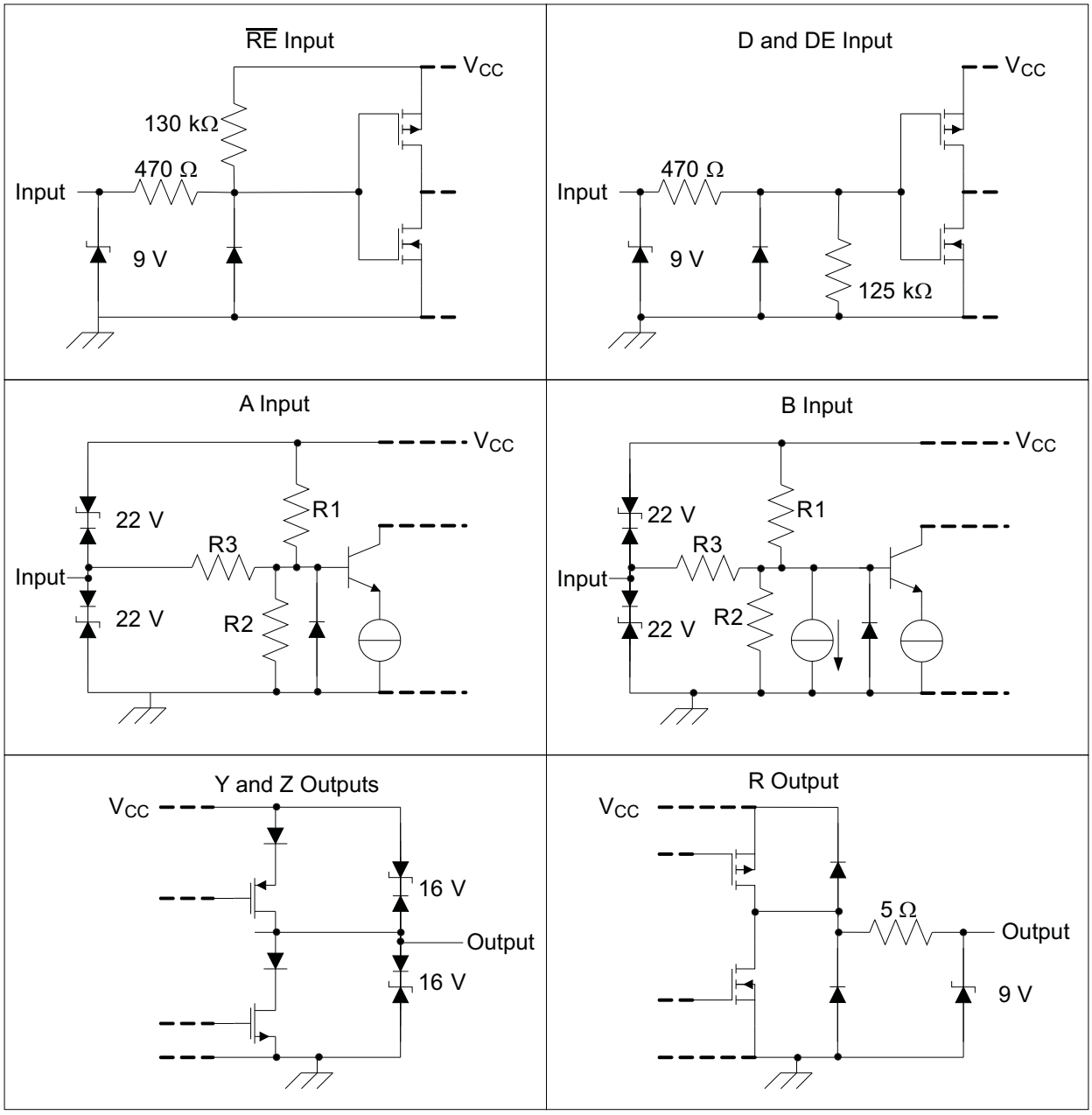


Figure 33. Equivalent Input and Output Schematic Diagrams

Table 7. Input Attenuator Resistance Values

PART NUMBER	R1, R2	R3
SN65HVD30, SN65HVD33	9 kΩ	45 kΩ
SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35	36 kΩ	180 kΩ

10 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The SN65HVD3x family consists of full-duplex RS-485 transceivers commonly used for asynchronous data transmissions. Full-duplex implementation requires two signal pairs (four wires), and allows each node to transmit data on one pair while simultaneously receiving data on the other pair.

To eliminate line reflections, each cable end is terminated with a termination resistor (R_T) whose value matches the characteristic impedance (Z_0) of the cable. This method, known as parallel termination, allows for higher data rates over longer cable length.

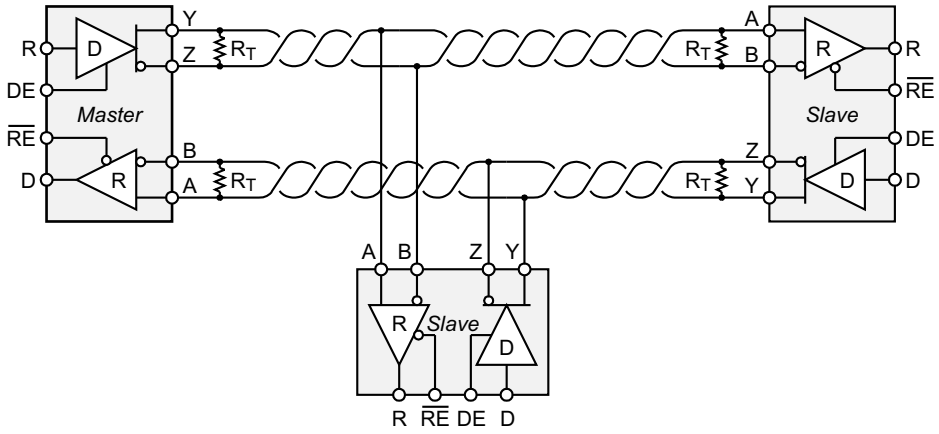


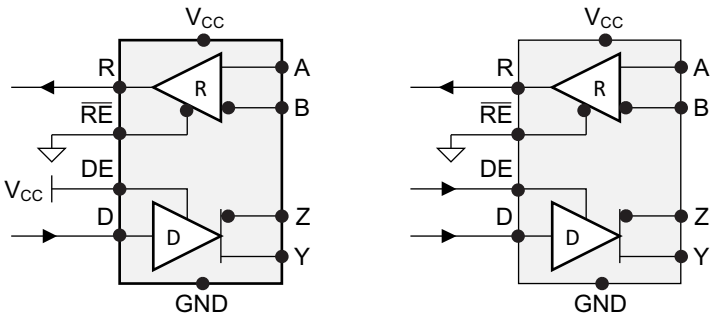
Figure 34. Typical RS-485 Network With Full-Duplex Transceivers

10.2 Typical Application

A full-duplex RS-485 network consists of multiple transceivers connecting in parallel to two bus cables. On one signal pair, a master driver transmits data to multiple slave receivers. The master driver and slave receivers can remain fully enabled at all times. On the other signal pair, multiple slave drivers transmit data to the master receiver. To avoid bus contention, the slave drivers must be intermittently enabled and disabled such that only one driver is enabled at any time, as in half-duplex communication. The master receiver can remain fully enabled at all times.

Because the driver cannot be disabled, only connect one driver to the bus when using the SN65HVD30, SN65HVD31, or SN65HVD32 devices.

Typical Application (continued)



a) Master enable control

b) Slave enable control

Figure 35. Full-Duplex Transceiver Configurations

10.2.1 Design Requirements

RS-485 is a robust electrical standard suitable for long-distance networking that may be used in a wide range of applications with varying requirements, such as distance, data rate, and number of nodes.

10.2.1.1 Data Rate and Bus Length

There is an inverse relationship between data rate and bus length, meaning the higher the data rate, the shorter the cable length; and conversely, the lower the data rate, the longer the cable can be without introducing data errors. While most RS-485 systems use data rates between 10 kbps and 100 kbps, some applications require data rates up to 250 kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

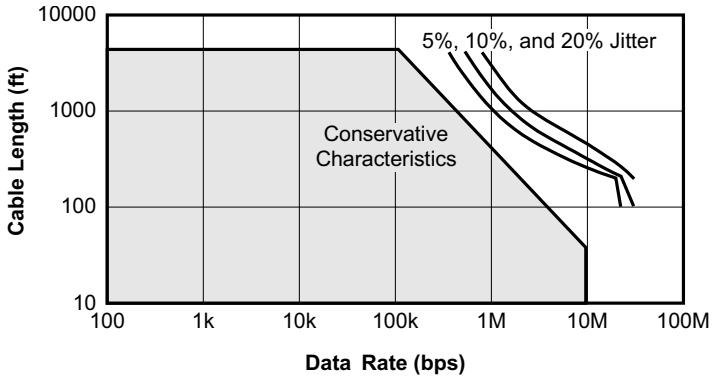


Figure 36. Cable Length vs Data Rate Characteristic

Even higher data rates are achievable (such as 26 Mbps for the SN65HVD30 and SN65HVD33 devices) in cases where the interconnect is short enough (or has suitably low attenuation at signal frequencies) to not degrade the data.

Typical Application (continued)

10.2.1.2 Stub Length

When connecting a node to the bus, the distance between the transceiver inputs and the cable trunk, known as the stub, must be as short as possible. Stubs present a nonterminated piece of bus line that can introduce reflections as the length of the stub increases. As a general guideline, the electrical length, or round-trip delay, of a stub must be less than one-tenth of the rise time of the driver; thus giving a maximum physical stub length as shown in Equation 1.

$$L_{stub} \leq 0.1 \times t_r \times v \times c \quad (1)$$

where:

- t_r is the 10/90 rise time of the driver
- c is the speed of light (3×10^8 m/s)
- v is the signal velocity of the cable or trace as a factor of c

Per Equation 1, Table 8 shows the maximum cable-stub lengths for the minimum driver output rise times of the SN65HVD3x full-duplex family of transceivers for a signal velocity of 78%.

Table 8. Maximum Stub Length

DEVICE	MINIMUM DRIVER OUTPUT RISE TIME (ns)	MAXIMUM STUB LENGTH	
		(m)	(ft)
SN65HVD30	4	0.1	0.3
SN65HVD31	25	0.6	1.9
SN65HVD32	120	2.8	9.2
SN65HVD33	4	0.1	0.3
SN65HVD34	25	0.6	1.9
SN65HVD35	120	2.8	9.2

10.2.1.3 Bus Loading

The RS-485 standard specifies that a compliant driver must be able to driver 32 unit loads (UL), where 1 unit load represents a load impedance of approximately 12 kΩ. Because the SN65HVD30 and SN65HVD33 devices are 1/2 UL transceivers, it is possible to connect up to 64 receivers to the bus. Likewise, the SN65HVD31, SN65HVD32, SN65HVD34, and SN65HVD35 devices are 1/8 UL transceivers that can support up to 256 receivers.

10.2.2 Detailed Design Procedure

To protect bus nodes against high-energy transients, the implementation of external transient protection devices is necessary (see Figure 37).

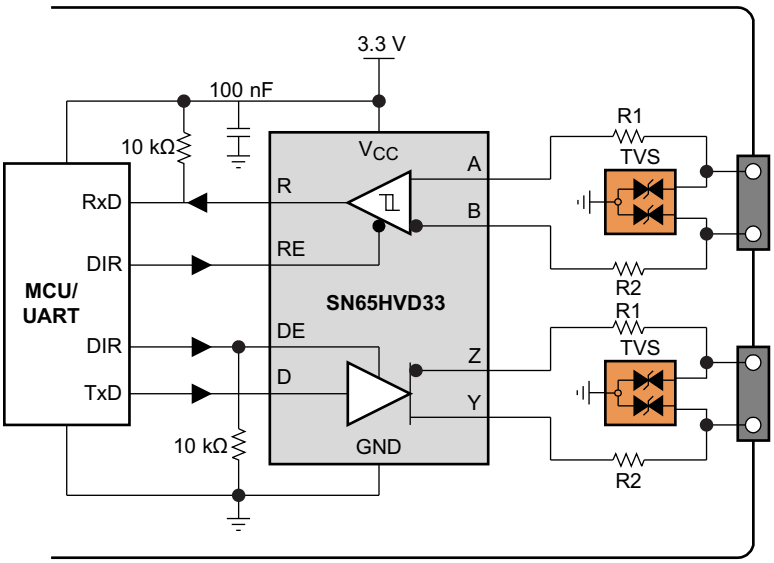
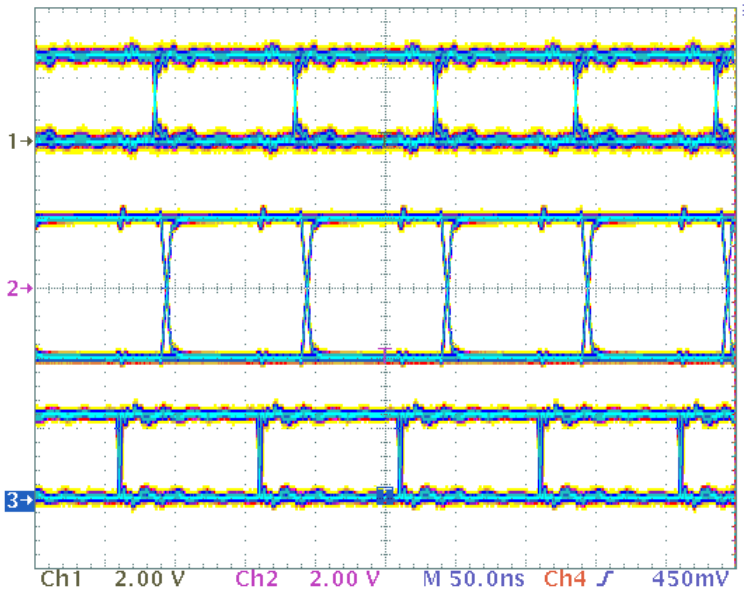


Figure 37. Transient Protection Against ESD, EFT, and Surge Transients

Table 9. Bill of Materials

DEVICE	FUNCTION	ORDER NUMBER	MANUFACTURER
XCVR	3.3-V Full-Duplex RS-485 Transceiver	SN65HVD33	TI
R1, R2	10-Ω, Pulse-Proof Thick-Film Resistor	CRCW060310RJNEAHP	Vishay
TVS	Bidirectional 400-W Transient Suppressor	CDSOT23-SM712	Bourns

10.2.3 Application Curve



Signals from top to bottom: D, Y, Z, VOD

Figure 38. SN65HVD33 Transient Waveform

11 Power Supply Recommendations

To ensure reliable operation at all data rates and supply voltages, each supply must be decoupled with a 100-nF ceramic capacitor located as close as possible to the supply pins. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps compensate for the resistance and inductance of the PCB power planes.

12 Layout

12.1 Layout Guidelines

Robust and reliable bus-node design often requires the use of external transient protection devices to protect against EFT and surge transients that can occur in industrial environments. Because these transients have a wide frequency bandwidth (from approximately 3 MHz to 3 GHz), high-frequency layout techniques must be applied during PCB design.

- Place the protection circuitry close to the bus connector to prevent noise transients from entering the board.
- Use V_{CC} and ground planes to provide low-inductance. High-frequency currents follow the path of least inductance and not the path of least impedance.
- Design the protection components into the direction of the signal path. Do not force the transients currents to divert from the signal path to reach the protection device.
- Apply 100-nF to 220-nF bypass capacitors as close as possible to the V_{CC} pins of transceiver, UART, and controller ICs on the board.
- Use at least two vias for V_{CC} and ground connections of bypass capacitors and protection devices to minimize effective via inductance.
- Use 1-kΩ to 10-kΩ pullup or pulldown resistors for enable lines to limit noise currents in these lines during transient events.
- Insert series pulse-proof resistors into the A and B bus lines if the TVS clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors limit the residual clamping current into the transceiver and prevent it from latching up.
- While pure TVS protection is sufficient for surge transients up to 1 kV, higher transients require metal-oxide varistors (MOVs), which reduces the transients to a few hundred volts of clamping voltage and transient blocking units (TBUs) that limit transient current to 200 mA.

12.2 Layout Example

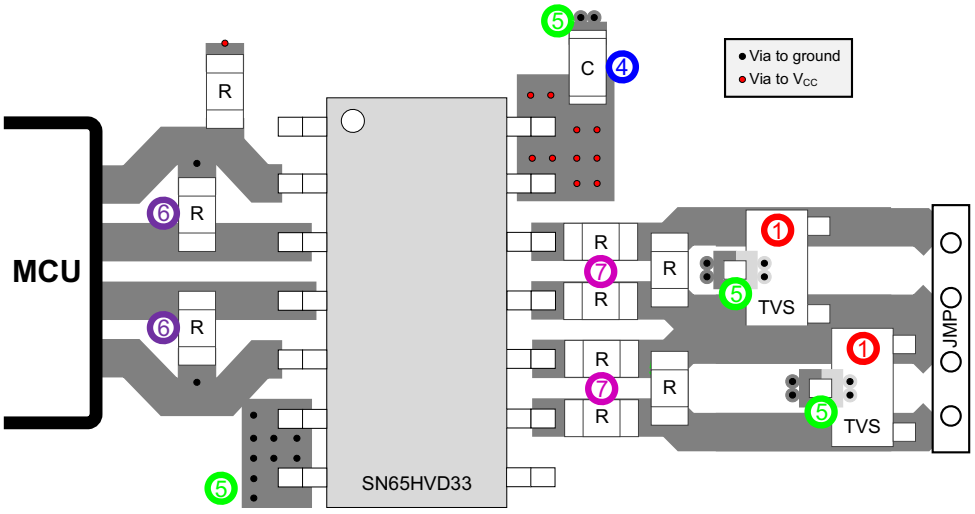


Figure 39. SN65HVD33 Layout Example

13 Device and Documentation Support

13.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

13.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 10. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
SN65HVD30	Click here	Click here	Click here	Click here	Click here
SN65HVD31	Click here	Click here	Click here	Click here	Click here
SN65HVD32	Click here	Click here	Click here	Click here	Click here
SN65HVD33	Click here	Click here	Click here	Click here	Click here
SN65HVD34	Click here	Click here	Click here	Click here	Click here
SN65HVD35	Click here	Click here	Click here	Click here	Click here

13.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

13.4 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

13.5 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

13.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

14 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65HVD30D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP30	Samples
SN65HVD30DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP30	Samples
SN65HVD30DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP30	Samples
SN65HVD30DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP30	Samples
SN65HVD31D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP31	Samples
SN65HVD31DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP31	Samples
SN65HVD31DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP31	Samples
SN65HVD31DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP31	Samples
SN65HVD32D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP32	Samples
SN65HVD32DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP32	Samples
SN65HVD32DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP32	Samples
SN65HVD32DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	VP32	Samples
SN65HVD33D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD33	Samples
SN65HVD33DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD33	Samples
SN65HVD33DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD33	Samples
SN65HVD33DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD33	Samples
SN65HVD33RHLR	ACTIVE	VQFN	RHL	20	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	65HVD33	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65HVD33RHLT	ACTIVE	VQFN	RHL	20	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	65HVD33	Samples
SN65HVD34D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD34	Samples
SN65HVD34DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD34	Samples
SN65HVD34DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD34	Samples
SN65HVD34DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD34	Samples
SN65HVD35D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD35	Samples
SN65HVD35DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD35	Samples
SN65HVD35DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD35	Samples
SN65HVD35DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	65HVD35	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

OTHER QUALIFIED VERSIONS OF SN65HVD30, SN65HVD33 :

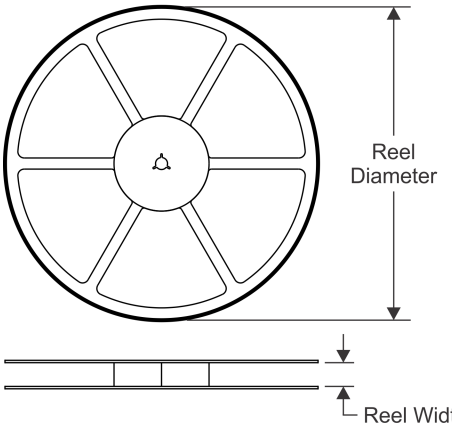
- Enhanced Product: SN65HVD30-EP, SN65HVD33-EP

NOTE: Qualified Version Definitions:

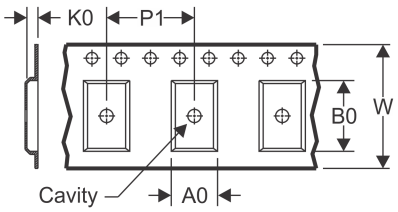
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

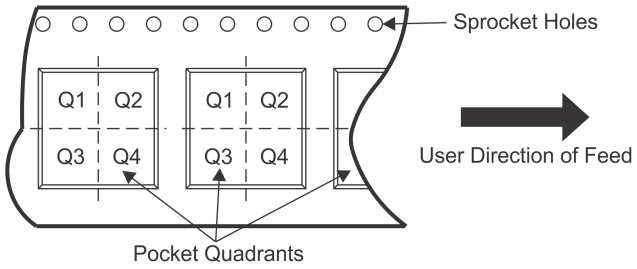


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

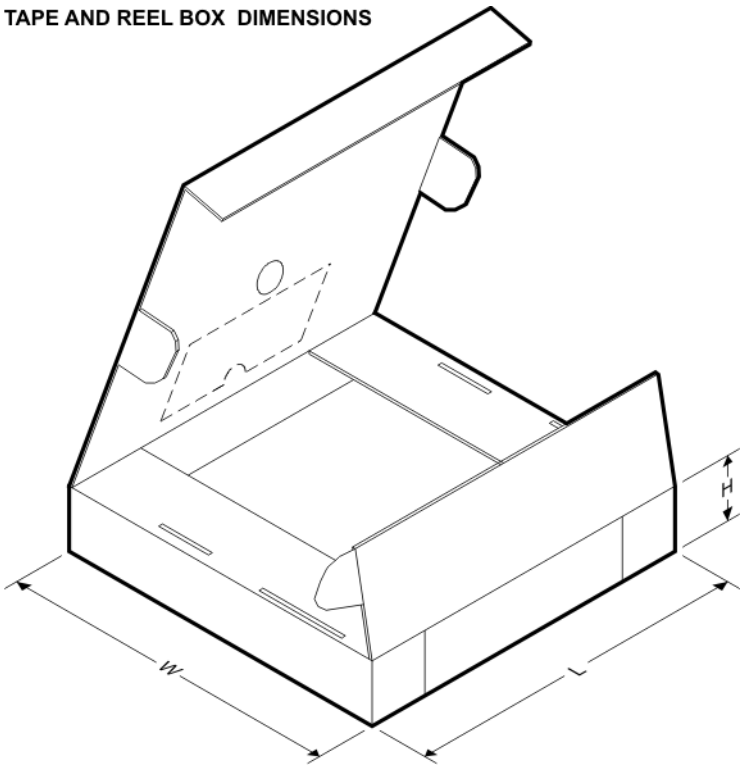
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN65HVD30DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD31DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD32DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD33DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD33RHLR	VQFN	RHL	20	3000	330.0	12.4	3.8	4.8	1.6	8.0	12.0	Q1
SN65HVD33RHLT	VQFN	RHL	20	250	180.0	12.4	3.8	4.8	1.6	8.0	12.0	Q1
SN65HVD34DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD35DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

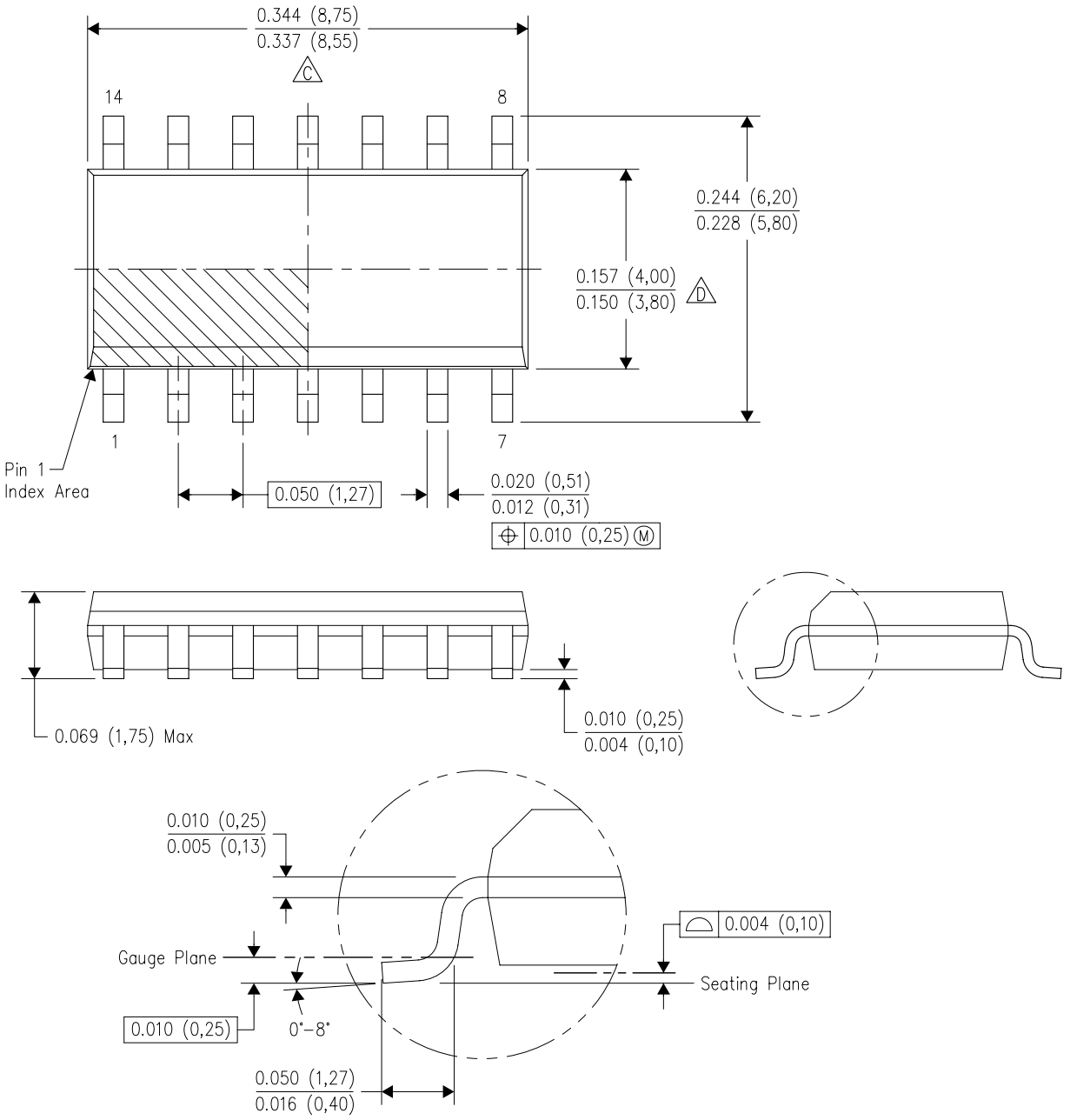
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65HVD30DR	SOIC	D	8	2500	367.0	367.0	35.0
SN65HVD31DR	SOIC	D	8	2500	367.0	367.0	35.0
SN65HVD32DR	SOIC	D	8	2500	367.0	367.0	35.0
SN65HVD33DR	SOIC	D	14	2500	367.0	367.0	38.0
SN65HVD33RHLR	VQFN	RHL	20	3000	367.0	367.0	35.0
SN65HVD33RHLT	VQFN	RHL	20	250	210.0	185.0	35.0
SN65HVD34DR	SOIC	D	14	2500	367.0	367.0	38.0
SN65HVD35DR	SOIC	D	14	2500	367.0	367.0	38.0

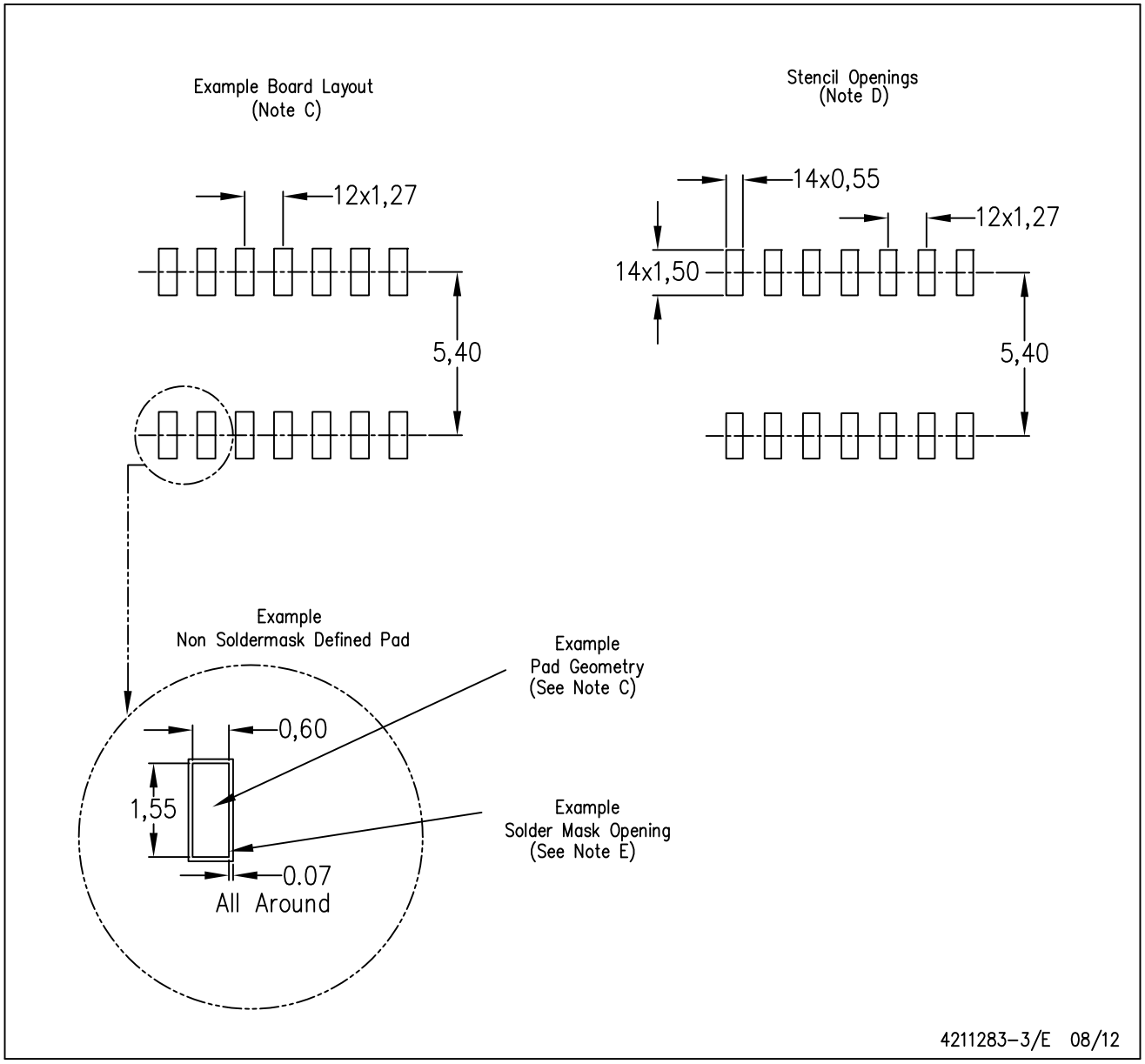
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

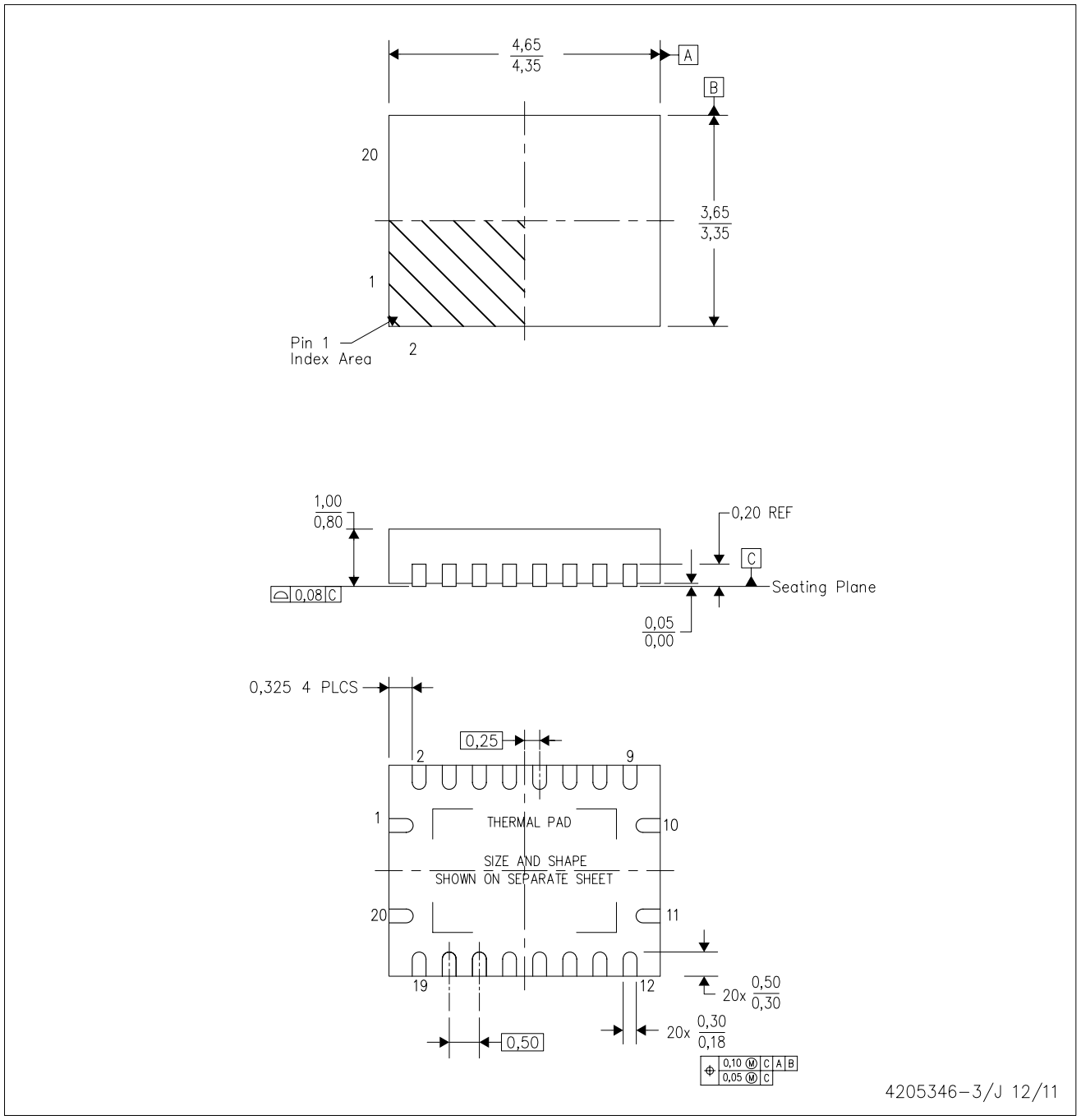
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

RHL (R–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) Package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

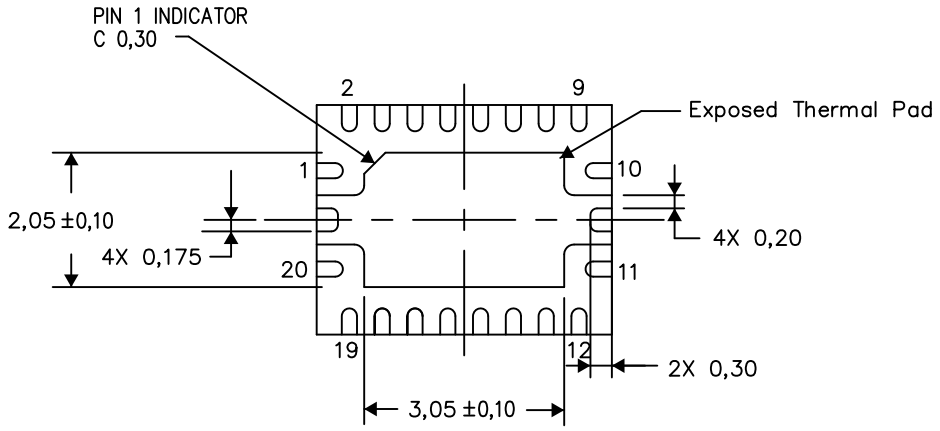
RHL (S–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



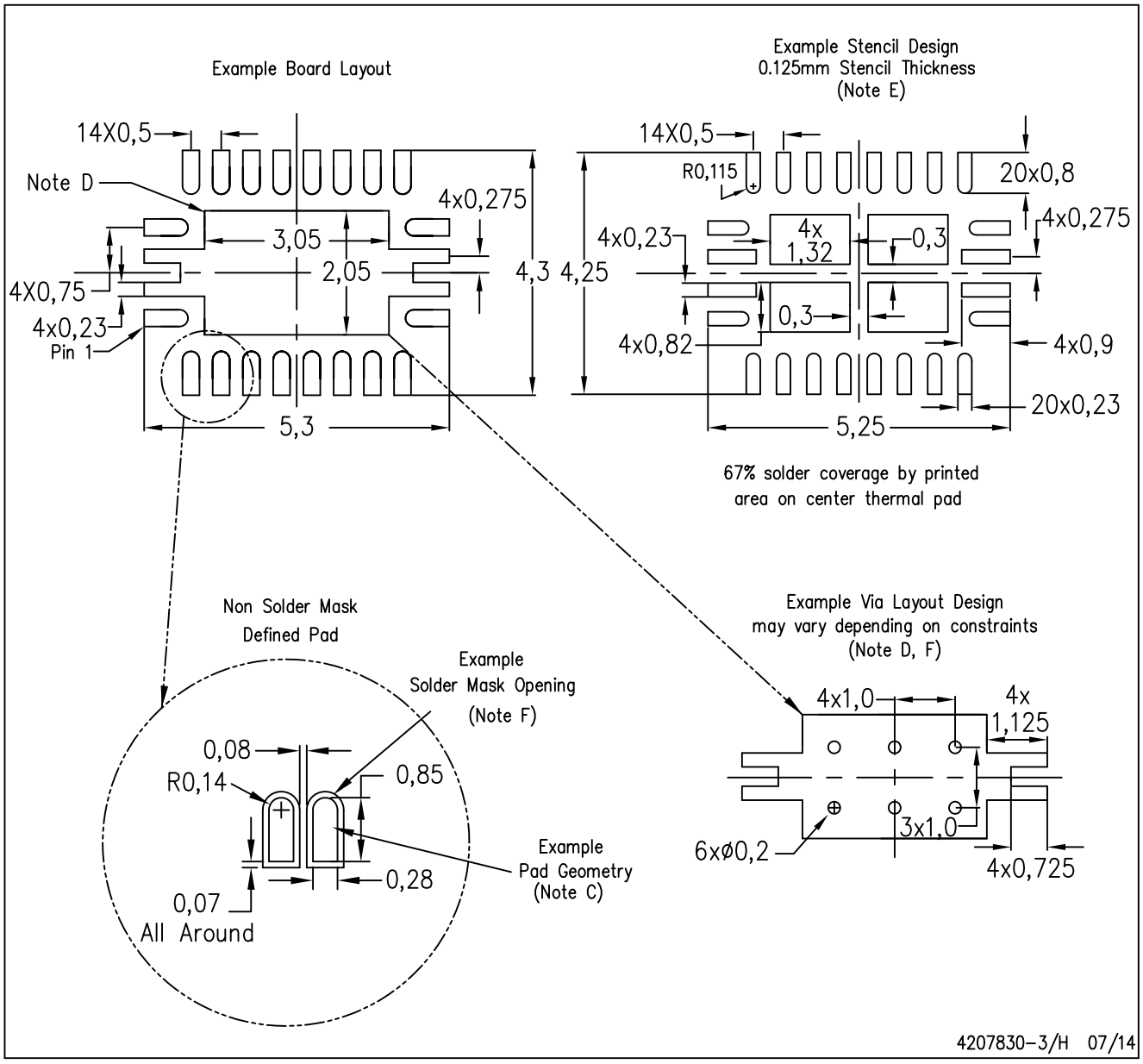
Bottom View

Exposed Thermal Pad Dimensions

4206363–3/N 07/14

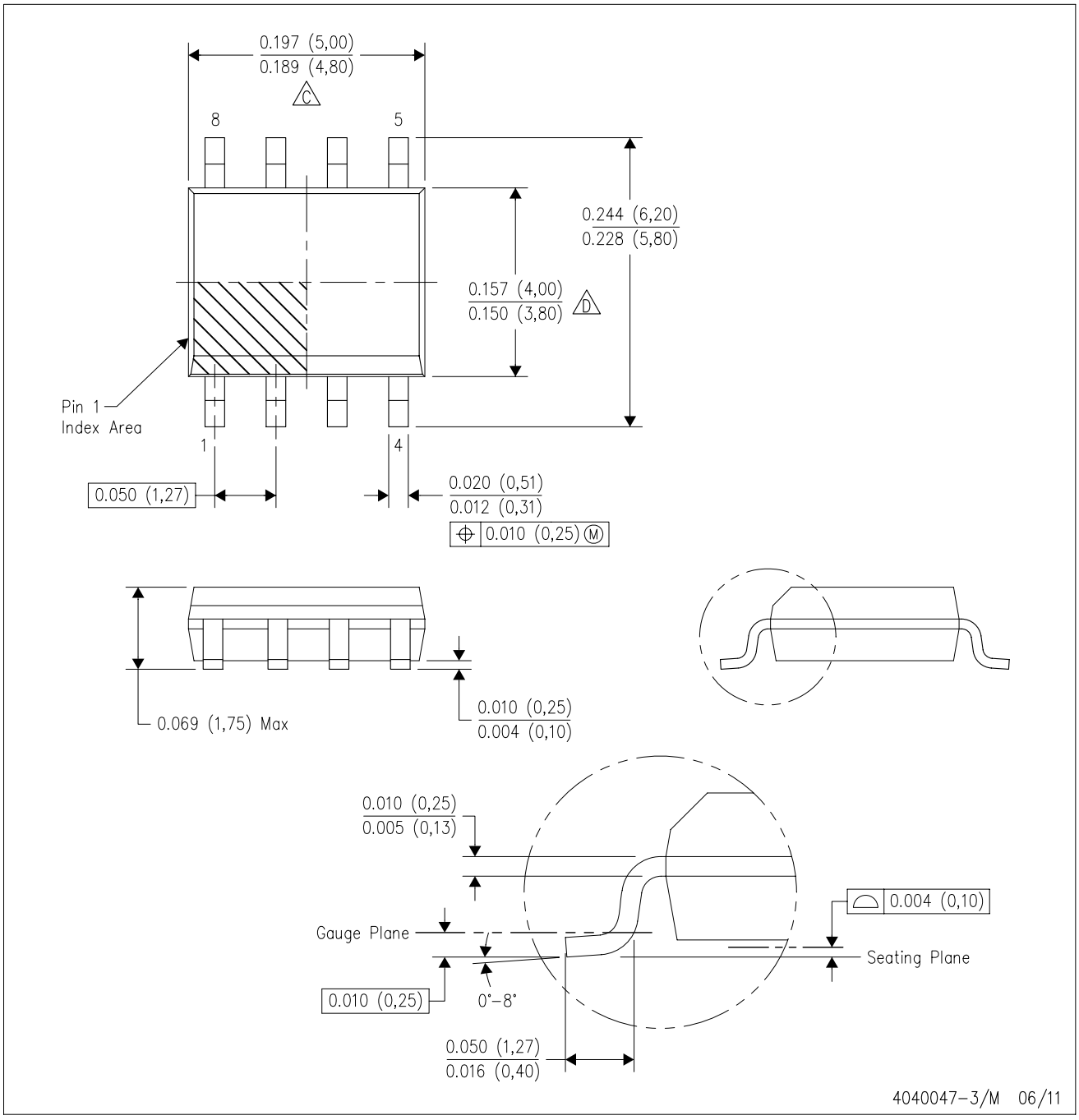
NOTE: All linear dimensions are in millimeters

RHL (R–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



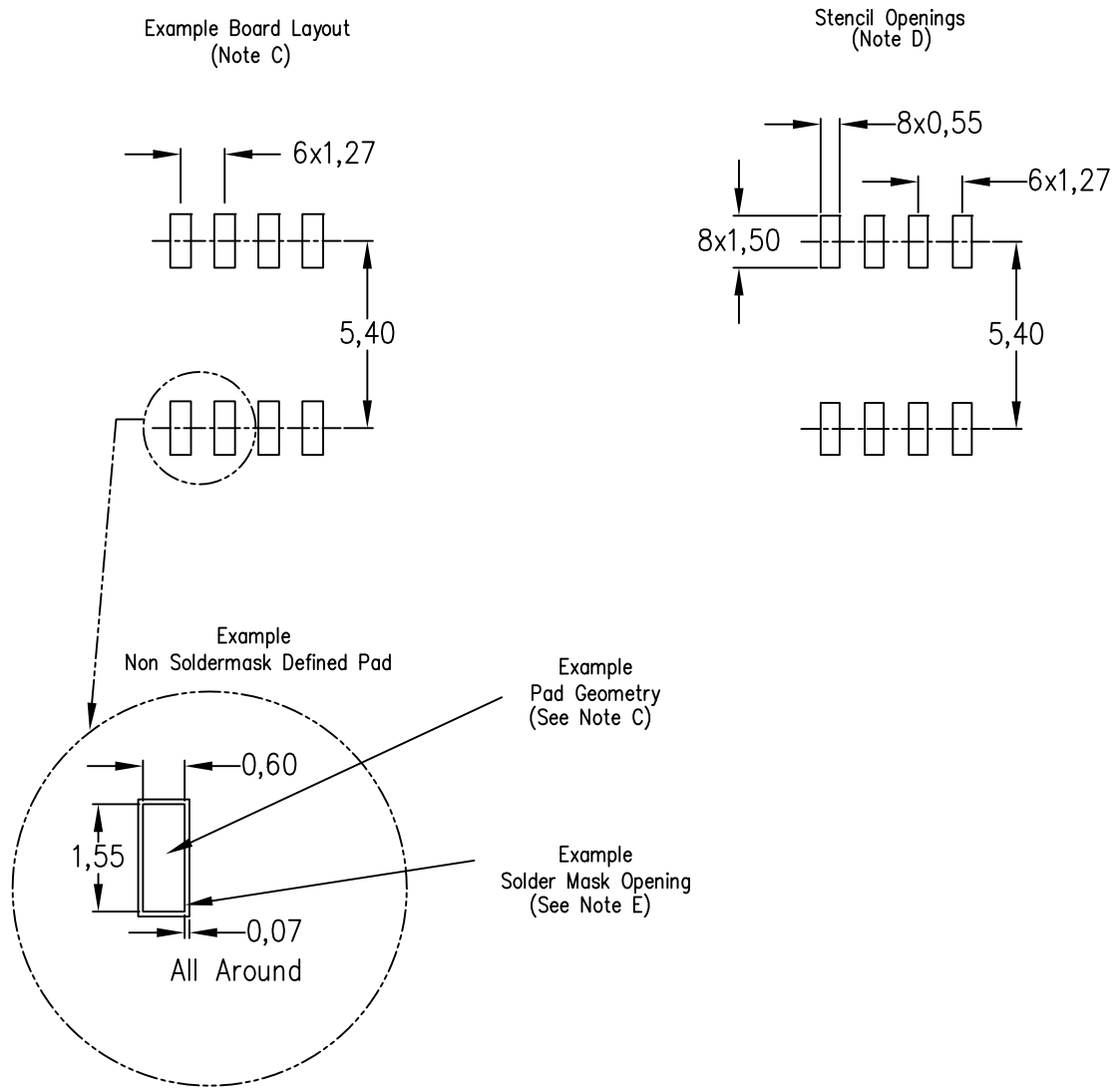
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AA.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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